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A Characterization of Maine Blueberry Growers in 2010

Anya Rose

A CHARACTERIZATION OF MAINE BLUEBERRY GROWERS IN 2010

By

Anya Rose

B.A. Bard College, 2005

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Advisory Committee:

Francis Drummond, Professor of Insect Ecology, Advisor

David Yarborough, Professor of Horticulture

Jim Acheson, Professor of Anthropology and Marine Sciences

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Thesis Advisor: Dr. Francis Drummond

An Abstract of the Thesis Presented
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A survey was sent to 343 lowbush blueberry growers in Maine with a response rate of 29%. Growers were asked questions about their management practices, pesticide use, priorities, decision-making influences, and beliefs about pesticide safety. Respondents categorized themselves into one of four categories: Integrated Pest Management (IPM), Conventional, Organic, and No-Spray. Analyses were conducted to examine factors that were linked to these four categories. A major goal of this study was to determine differences and similarities between growers of different management styles, and to *define* each category by the practices and beliefs of its members. Toxicity ratings were also calculated for each grower according to the pesticides they used, and correlations between toxicity rating and other factors are noted.

The majority of blueberry growers, regardless of farm type, prune at least part of their fields by mowing, use bees for pollination, earn income from another job, and are influenced by the Extension in their management decisions. Blueberry

growers of all management styles also noted family, neighbors, and other farmers as strong influences, and indicated little to no influence, on average, from mass media sources.

There were few significant differences between grower groups in priorities. Many growers noted, "making a profit" and "maintaining the value of the land" among their top three priorities. "Providing healthy food for the public" was a major priority among organic growers, and IPM and conventional growers prioritized "continuing my family's legacy" significantly higher than the other two groups. Likewise, there were few correlations found between management style and age or education. I discuss this it relates to the Diffusion of Innovations Theory. I also discuss adoption of practices that encourage native pollinators, and relate adoption of these practices to the same theory.

IPM growers were found to be similar to conventional growers in many of their practices, but they monitor for insects and take leaf tissue samples significantly more than conventional growers. These two practices, as well as higher dependence on income made from blueberries, may be what distinguish IPM growers from conventional. I also discuss the label, "Conventional," and suggest an alternative term that might be applied this category of grower instead.

No-Spray growers were found to be similar to organic in the majority of their practices and in beliefs about pesticide safety. No-Spray growers have been called, "non-certified organic" in other studies because their practices are thought to be very similar to those of organic growers, save for the actual certification. I found this to be true of Maine blueberry growers as well.

I propose separating Maine blueberry growers into just two, over-arching categories: "Pesticides Used" (includes IPM and conventional growers) and "Low-to-No Pesticides Used" (includes organic and no-spray growers). I discuss how viewing growers in this way allows for a better understanding of the communities, their practices, beliefs, and influences.

Because IPM was found in this study to be similar to Conventional in many regards, I also research IPM certification programs that have been successful in other states and propose that Maine follow suit.

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INTRODUCTION

Overview

Maine produces 97 percent of the lowbush blueberries, *Vaccinium angustifolium* Ait., in the United States (Strick and Yarborough 2005). The state is the largest producer of wild blueberries in the world, followed closely by several provinces in northeastern Canada. Sixty thousand acres are managed in Maine for blueberry production, and an average of more than 70 million pounds of berries are produced annually. Management techniques continue to improve and allow for higher yields (Yarborough 2009; 2004). Consumer demand for healthy food is likewise increasing, as is research on the health benefits of blueberries (Smith et. al 2000; Sweeny et. al 2002; Kristo et. al. 2010). New information about healthy food and about the toxicity of pesticides in relation to human health and the environment may cause consumers to make conscious choices about what they select to eat (Williams et. al. 2001; Wilson and Tisdell 2001; Aliouane 2009, Margini et. al. 2002; Pimentel et. al.1998; Govindsamy et. al. 1998; Anderson et. al. 1996). Whether the dangers of pesticides are real (Wilson and Tisdell 2001; Anon. 2009; Pimentel et. al. 1998) or only perceived, personal beliefs have been documented in many studies as affecting consumer behavior (Williams and Hammitt, 2001; Blake 1995). Are blueberry growers taking part in the movement to reduce pesticide use? If so, which growers, and how? Because it is possible for blueberries to be managed with low-input methods, and because they are in high demand, I believe they are prime candidates for the study of how farmers adapt to new demands and changing technologies.

The present study is based on a survey that I sent to all wild blueberry growers on the Maine Cooperative Extension wild blueberry mailing list during the spring of 2010. This inventory of growers represents most of the wild blueberry growers in Maine, organic, IPM and conventional producers. My objective was to **compare** growers from a range of different management styles, from low input, to certified organic, to varying levels of IPM (Integrated Pest Management), to "traditional" or "conventional." I examined the demographics and philosophical priorities of wild blueberry growers, investigated their beliefs regarding pesticide safety, and analyzed factors that influence their decision-making, as well as analyzed the categories that blueberry growers place themselves into when filling out the survey. I attempt to provide insight into whether IPM growers are different from conventional growers, and whether no-spray growers are different from organic. How do these groups compare and contrast to one another, and what distinctions are worth making between grower groups? I conclude my analysis by quantitatively defining differences and similarities between grower groups

This information might allow future university researchers and Cooperative Extension faculty to make more accurate generalizations regarding categories of growers, as well as to determine how best, and to whom, new information should be directed. This study also aims to capture the state of the wild blueberry industry as it exists in Maine in 2010, and provide a benchmark for future studies . In addition, my findings allowed me to address some costs and benefits of initiating an IPM certification program for wild blueberries in the state of Maine.

History

The most recent characterization of Maine's blueberry growers was conducted in 2008 (Files et. al. 2008) and looked specifically at organic growers and their pest

management practices. A previous study (Metzger and Ismail 1976) described the management practices of wild blueberry growers who were provided with the management recommendations from the University of Maine Cooperative Extension. The results of these two studies were compared with the results of my study to determine how Maine's wild blueberry industry might have changed over the 34-year period.

It is estimated that 854 of the 60,000 acres of Maine's wild blueberry production are organically managed and organic production is projected to increase (Drummond et. al. 2009). Efforts are also being undertaken internationally to implement Integrated Pest Management (IPM) to reduce unwarranted use of pesticide, and to encourage the use of less toxic pesticides (Anon. 2009; Fernandez-Cornejo and Jans 1999; Anon. 2001). The University of Maine Cooperative Extension provides research, advice, online forecasting services, and consultations to wild blueberry growers about effective methods in pruning, fertility, and integrated pest management. Research has shown that IPM methods in many cropping systems is more productive, less costly, and less harmful to the environment than conventional methods (Pimentel et. al. 1998), yet some communities of growers are still reluctant to adopt IPM both nationally (Hammond et. al. 2006; Kaine and Bewsell 2008;) and internationally (Wilson and Tisdell, 2001; Ricker-Gilbert et. al. 2008). My hope is to provide insight into how Maine wild blueberry growers fit into nation-wide movements in agriculture, including adoption of both IPM and organic practices.

Methods of Management

Lowbush blueberries can be managed very minimally, simply by burning the fields to keep them in the early stage of succession. This is the method that the Native Americans are thought to have used (Strick and Yarborough 2005). As Europeans began

to settle the area, they too took advantage of the berries that grew wild. In the late 1800s, settlers began to privatize land. Production methods became more deliberate and intensified in the 1960s with increased pruning, and by the 1970s, fertilization, weed control, and pest management became actively practiced (Yarborough 2009).

Weeds

Weeds are a major limiting factor in blueberry production (Jensen and Yarborough 2004). Weed management can take the form of herbicide applications, hand pulling, and mowing or cutting weeds. Herbicides can be applied at the beginning of the growing season before weeds emerge (pre-emergence), or after the weeds have sprouted (post-emergence) (Jensen and Yarborough 2004). Improvements in weed management have allowed blueberry yields to double in some areas (Yarborough 2004).

Some wild blueberry growers choose to fertilize their fields with synthetic fertilizer. Fertilizer can promote the growth of weeds in addition to growth of the desired crop, but recent, improved methods of weed control make fertilization more effective than before (Yarborough 2004). Alternatively, some growers add sulfur to the soil, as a form of weed control. Blueberries can tolerate a low pH compared to many other plants, and periodically adding sulfur decreases the pH of the soil and prevents the growth of weeds less tolerant of low pH (Yarborough 2004).

Pruning

Most wild blueberry growers manage their fields on a two-year cycle, pruning half of their crop field, while managing the other half for fruit production (Metzger and Ismail 1976; Yarborough 2009). This allows the fields to remain in the early stage of succession in which blueberries thrive. Pruning can take the form of mowing, or burning with straw, hay, or oil (Metzger and Ismail 1976). While effective at minimizing disease

and killing weeds and insect pest eggs, fire consumes the organic soil layer, which would otherwise serve as nutrients for blueberries, upon decomposition. Burning is also expensive (Yarborough 2009; Metzger and Ismail 1976) and pollutes the air. Ismail and Yarborough (1979) showed that mowing to within a centimeter of the ground, while not as effective at minimizing pests, is effective at keeping blueberries healthy by preserving the soil environment and leaving organic matter on the ground. Burning by oil is still used however, especially in areas where large boulders and uneven terrain prevent the close mowing that's needed to prune properly (Yarborough 2004). Burning with straw is also used by some growers, but is now less common because of the amount of time and labor required (Yarborough pers. com.).

Disease

Fungal diseases pose a threat to blueberries as well, especially during foggy or rainy weather. In 2009, the fungus *Valdensinia heterodoxa,* a new pathogen to wild blueberries in Maine, reduced blueberry yield in fields where it was found. Travel between fields with contaminated equipment and vehicles was thought to have greatly increased the likelihood of infection, as did the extremely wet weather (Annis pers. comm.). Mummy berry, caused by *Monilinia vaccinii-corymbosum,* and red leaf disease, caused by *Exobassidum vaccinii,* are other diseases which can cause significant damage (Annis and Stubbs 2004). Fungicide applications can be made according to the calendar year at specific times each year, by monitoring for exact locations of fungal infections, or according to an online, "Disease Forecasting Service," which notes current weather conditions and estimates likelihood of mummyberry infections (Annis pers. com.). Burning can also serve to suppress some types of fungal diseases (DeGomez et. al. 1990; Yarborough and Annis 2010).

Insects

Insect pests can be controlled by burning, application of insecticides, or by natural enemies acting as biological controls. Different species of insect pests and specific insect pest life stages are targeted using particular control tactics (Yarborough and Drummod 2010; Yarborough et. al. 2001; Dill et. al. 2001), and knowledge of ecology and insect biology is essential in determining which method to use. For example, Bt, or *Bacillus thuringiensis*, is a microbial toxin that is specific to insect pests in the order Lepidoptera. This order includes blueberry spanworm (*Itame argillaceria*) and red-striped fireworm (*Aroga trialbamaculella* Cham.), both leaf-feeding pests of wild blueberry. Plant leaves sprayed with Bt toxin are ingested by the pest, which results in the inhibition of digestion in the larvae. Bt will affect non-pest immature moths and butterflies (D'Appolinio et. al 2010) but also will not affect the caterpillars of sawflies (*Pristophora)*, blueberry sawfly (*Neopareophora litura*) being a pest of wild blueberry (Collins et. al 1994). Therefore, it is important for growers to have knowledge about the specific insects that appear in their fields. It should be noted that, while some growers make the distinction between herbicides and pesticides, the term "pesticide" will be used throughout this paper to refer to any type of chemical used to control a pest, including insects, weeds, and plant pathogens.

Pollination

Critical to blueberry production is bee-mediated pollination (Drummond and Stubbs 2003; Drummond 2002). Past data has shown that the majority of growers rent honeybees for their fields to increase yield (Files et. al. 2008; Strick and Yarborough 2005; Metzger and Ismail 1976). Honeybees are rented during bloom and then brought to other crops (often cranberry or apples) after blueberry flowers have been pollinated.

However, honeybee populations have decreased in the past few years due to a multitude of potential causes such as Colony Collapse Disorder (CCD), fungal and mite infections, pesticides, habitat alteration, changing weather patterns, and long distance trucking (Drummond 2002). In addition, honeybees are not as efficient at pollinating blueberry as native bees on a per bee basis and take longer to pollinate a single flower than bumble bees or other native bees (Stubbs et. al. 1997; Drummond and Stubbs 2003). Recent efforts, including fact sheets, workshops, and demonstrations, have been put forth by the University of Maine Cooperative Extension to assist growers in the conservation of native pollinators and use of commercial bumble bees in lieu of honey bees (Stubbs et. al. 2002: Stubbs et. al. 2007; Drummond and Stubbs 2003).

Providing nesting habitat is important for conserving both native and non-native pollinators, and populations of native bees can be actively enhanced if growers allow certain flowers other than blueberries to bloom to serve as alternate food sources (Drummond and Stubbs 2003). Research has also indicated that native bees prefer small fields over large ones because of the ratio of field edge habitat. (Drummond and Stubbs 2003). In general, the more diverse the habitat and the more diverse the plants, the more native bees and the more *diversity* in native bees a field will have. For this reason, the University of Maine Cooperative Extension encourages growers to leave field edges containing flowering plants.

Some growers may not realize that certain pesticides are harmful to beneficial insects such as bees. Detrimental effects on beneficial insects can be reduced by refraining from applying pesticides during times when those insects are active and present in the field, or by avoiding specific locations, such as the shrubs at the edges of

fields where many native leafcutting bees make their nests (Stubbs et. al. 2000). Selection of insecticides also can play an important role in bee conservation as some are more toxic to bees than others (D'Appollonio et. al. 2010; Drummond and Stubbs 2003). The University of Maine Cooperative Extension has published and disseminated information for growers and conducted demonstrations on many aspects of bee conservation (Collins et. al. 1994; Drummond and Stubbs 2003; Stubbs et. al. 2000; Stubbs et. a. 2002; Stubbs et. al. 2007).

The Four Management Styles

Growers have different beliefs regarding farming practices, including the use of synthetic pesticides and fertilizer. Some growers do not synthetic chemical inputs at all, others use them sparingly, and others use these inputs intensively. The toxicity of pesticides is complex and growers are required to keep detailed records of their applications by the Maine Board of Pesticide Control. Many pesticides may be toxic in one regard, but non-toxic in another. Harmful side effects to humans or other non-target organisms depend on the type of pesticide used, the application method, dose, timing, weather conditions during time of application, as well as a host of other factors (Banerjee 1999; Margini 2002). For example, research shows that the insecticide, acetamiprid, effectively controls blueberry maggot (Yarborough and Drummond 2010), but may also harm honeybees if applied in conjunction with fungicides that contain the active ingredient propiconizole (D'Appollonio et. al. 2010; Iwasa et. al. 2004). Method of application, breakdown in the environment, synergistic effects, effects on no-target organisms, and residues that remain on the crop, which may then be consumed by humans or wildlife, are all factors to consider when using pesticides (Pimentel et. al. 1998; Drummond and Stubbs, 2003; Jensen and Yarborough 2004; D'Appollonio et. al.

2010). Pesticides can have complex ecological effects as well as subtle externalities, and many side effects are still unknown (Pimentel et. al. 1998). Fertilizers applied to wild blueberries can also cause indirect unintended negative effects such as soil degradation and increases in weed resistance (Jensen and Yarborough 2004). For these reasons, some growers may choose to use less pesticide on their fields and others may choose to use no synthetic pesticides at all. Four different styles of management have emerged, both in blueberry growing and in other cropping systems. These styles involve various practical and moral philosophies, and are each discussed below.

Conventional

Conventional growers use pesticides in the traditional, prophylactic sense. This implies that pest management tactics are employed without necessarily having full knowledge of pest presence, pest vulnerability, ecological disruption, or economic cost/benefits of the control tactic (Anon. 2004; Fernandez-Cornejo 1999; Comer et. al. 1999). They may spray according to the calendar year, applying pesticide on the same dates every year, or according to "rules of thumb," such as after the last, heavy spring rain. Some growers are certified to apply pesticides, while others hire contractors. Those who hire out may be forced to have their fields sprayed only when certified applicators and/or pilots are available. Situations like that may not always leave room for consideration of timing, weather, or for refraining from spraying in areas where pests are not a threat. Conventional growers are typically thought of as having a lower priority for reduced environmental impact than other growers, and as maintaining highly mechanized operations, with high inputs of synthetic pesticide and fertilizer (Comer et. al 1999).

Whether this applies to conventional blueberry growers will be determined in the analysis.

It should also be noted that in order to spray the more toxic, restricted use pesticides, or to spray on property other than one's own, an applicator in Maine must obtain a Maine Pesticide Applicator's License. This requires passing an examination and then attending workshops, demonstrations, and lectures throughout the year, and obtaining 18 credits over a two-year period for a master license.

Integrated Pest Management

Integrated Pest Management (IPM) has been described in a number of ways and involves utilization of many different management practices together (Zalucki et. al. 2009; Fernandez-Cornejo and Jans 1999; Anon. 2004; Yarborough et. al. 2001). The original goal of IPM was to reduce the use of pesticides in order to increase farmer profitability. More recently however, the reasons for using less pesticide have shifted, especially on the part of the public, and concern over environmental quality and human health are now major reasons for IPM adoption (Fernandez-Cornejo and Jans 1999). The IPM management philosophy is based on using many different methods at once, including: monitoring for pests and spraying only if economically necessary, understanding the biology of pests including most efficient and effective times for management, monitoring soil temperature for predications of pest occurrence, preventing spread of disease by sanitation, mulching bare spots to reduce weeds, leaving certain areas unsprayed and/or unmowed to attract natural enemies, managing weeds before they go to seed, monitoring weather patterns for likelihood of fungal disease outbreaks, and many other practices (Pedigo and Rice 2006). Integrated Pest Management, by definition,

involves utilizing a diverse (integrated) set of practices, taking the whole ecosystem, and also farm economics, into account when making decisions about control of pests.

Organic

Organic farming gained momentum nationwide in the 1960s with the back-to-the-land movement, and with Rachel Carson's publication of Silent Spring (Vos 2000). People began to show more concern over the effects of pesticide use. Some vowed to use only organic inputs, other vowed not to use any pesticides at all. But in addition to the specific practices, some believe "organic" has an underlying spirit to it as well, which may be difficult to measure. Vos (2000) describes it in this way:

> *Organic farming can be thought of as a kind of "ecological-resistance movement" (Taylor 1995), both challenging the hegemony of the agro-industrial paradigm, and proposing and exploring alternative society-nature relations.*

In short, "organic" can be defined as a method of sustainable agriculture that avoids the use of synthetic pesticides and fertilizers (Altieri 1995). In 1990, the USDA came out with The Organic Foods Production Act, which has since been revised (Anon. 2005). The standardization of organic has been controversial. Some argue that standardization has prevented "cheating" (calling produce organic when it is not), and has allowed the organic style of management to become more widely known among consumers (Vos 2000). Others, including many small, organic growers, see standardization as undermining their grassroots efforts, and allowing large, industrial farms to co-opt the term (Guthman 1998; Vos 2000).

Requirements are quite stringent to become a certified organic grower in Maine. Farmers must comply not only with the National Organic Rule, created by the USDA (Anon. 2005), but also with the rules set out by the Maine Organic Farmers and Growers Association (MOFGA). All products that are used as pesticides must also be registered with the state of Maine after registration of those products has been approved by the Federal Environmental Protection Agency. These growers must go through a strict certification process before they can officially label themselves as organic.

No-Spray

Because the organic certification process can be costly and time-consuming, some farms in Maine may use little to no chemicals, but may not be officially certified as organic by MOFGA. Some growers may use very low-input methods due to philosophical reasons, others may do it because they happen to have blueberries on their land but do not wish to actively manage them.

Some studies have suggested that there is now a bifurcation between certified organic and non-certified organic, with the former being adopted by the larger, more industrial farms that sell to indirect markets, and the latter continuing with the small farms that may not be able to afford certification, and that tend more to sell in direct markets. There may be a growing body of farmers whose consumers simply trust them, even without the official certification (Constance et. al. 2008). The present study uses these four categories, Conventional, IPM, Organic, and No-Spray, to examine blueberry growers of Maine.

Theoretical Framework

The Diffusion of Innovations Theory describes how societies come to adopt a new technology. Conceived in the late 1800's, the theory was made more widely known by E. M. Rogers in the 1960s (Rogers 1971; Padel 2001). One aspect of this theory proposes that once an innovation has been adopted by 15-20% of the community, adoption by the rest of the community will likely follow. Another aspect of this theory is that those who are the first to adopt a new innovation (called, "Early Adopters") are more likely to be younger, more highly educated, and to maintain more contact with change agents and the "outside world" than those who are more reluctant to adapt (called, "Laggards") (Rogers 1971). In terms of wild blueberry production, I will use this theory to examine the grower groups that are most likely to adopt a new technology (i.e. can IPM growers be considered early adopters?) and to look into the demographic characteristics of each grower group (i.e. are IPM growers younger than conventional?). The Cooperative Extension will serve as the "change agent" in these scenarios, and new techniques suggested by the Extension will serve as the innovations to be adopted.

METHODS

The Survey

Surveys (see appendix) were sent with self-addressed, stamped envelopes in April 2010 to all 343 growers on the University of Maine Cooperative Extension wild blueberry producer's list. This includes all growers who were then defined as either IPM, Organic, or Conventional, which consisted of growers of both small (part-time) and large (full-time) farms, as well as growers who own blueberry land in Maine but who live out of state. Those who manage blueberries on someone else's land are also included, as many small landowners hire others to manage their land. Surveys were returned anonymously.

I attended two "Twilight Meetings" in March 2010, one in Ellsworth and the other in Machias, where I met some of the growers and briefly explained that they would be receiving a survey in the mail in a few weeks. I attended the meetings with the University of Maine Cooperative Extension faculty, with whom all growers were already acquainted, and administered a preliminary, pilot survey to eight growers to provide suggestions for revisions. The final survey was drafted and respondents were asked to respond by 15 May. Reminder postcards were sent during the week of 2 May. No incentives or gifts could be offered, since the survey was administered by mail and was anonymous. On 21 July, additional surveys were handed out during the Blueberry Grower "Field Day" at Blueberry Hill Farm, Jonesboro. The survey was announced just prior to an hour and a half lunch break. Growers at this event were offered a free hat in return for their participation in the survey. We received 126 completed surveys by mail, and were able to use 100 of them, which gave a response rate of 29%.

The survey consisted of thirty-eight questions on twelve pages. I collected information on demographics, background information, and management practices of each grower. One question on the survey asked, "How would you categorize your management style overall?" Growers could choose between Organic, No Spray, Conventional, and IPM, and each category contained sub-categories by which respondents could define what they meant by their own categorization. The survey also included questions in three areas: "Scientist-Grower Relationships," "Factors of Personal Importance," and "Influences and Communication." Questions in the first area asked respondents to rate their level of agreement, from 1 to 5, with statements about their interactions with the University of Maine Cooperative Extension faculty in regards to pesticide safety. Questions in the second area required growers to rank a series of ten priorities, or goals, from most important to least important. Questions contained in the third area asked respondents to rate, on a scale of 1 to 5, avenues of information acquisition that are least and most influential to them in adopting new farming practices.

Toxicity Rating Scale

Growers were asked to name any pest management pesticides they used, including insecticides, herbicides, and fungicides, and including organically approved pesticides. They were also asked the number of times per year they applied each chemical. Pounds of pesticide applied per acre was not specifically asked for on the survey. It was assumed that growers apply the rate indicated on the label, which is required by state and federal laws. Each pesticide was given a numerical ranking according to its level of toxicity, using the 2010 Maine Wild Blueberry Pesticide Chart (D'Appollonio et. al. 2010). The chart includes a combination of symbols next to each pesticide, which indicate that pesticide's relative toxicity to fish, bees, birds and people.

Those with the symbol that noted, "extremely toxic to fish," for example, were given 3 points, while those that were "moderately toxic to fish" were given 2 points. The same was applied to extreme and moderate toxicity for bees and birds. For humans, moderate toxicity was assigned 3 points, and extreme toxicity was assigned **4 points. One** point was allotted for pesticides for which no *known* harmful effects have been noted. A score of zero was reserved for growers who used no pesticides. Fertilizer and sulfur were not considered in the pesticide toxicity rating. Toxicity indices were summed for each pesticide, and growers were assigned ratings which comprised indices from the types of pesticides used, multiplied by the number of times per year they applied each pesticide. The lowest toxicity rating a grower could receive was zero (for using no pesticides at all). The herbicides ranked lowest on the index, most had levels of 1, except for flazifop-p-butyl (Fusilade DX^{TM}), which received a score of 6. The most toxic pesticide was the insecticide, phosmet (Imidan^{TM}) which received a score of 11.

There were some growers who did not note the specific pesticides they used, but their answers to other questions indicated that they use them. Growers for whom the toxicity rating was ambiguous were not included in specific analyses regarding pesticide toxicity. It should be noted that this rating system is highly superficial. There are many factors that are not taken into account, and these will be discussed in the results section.

Exclusions

I received 126 returned surveys, but 26 were excluded. Three respondents lived out of state (MI, TX, and Quebec) and maintained no fields in Maine. Eleven said that they hire a private wild blueberry company to manage their fields. Some of these

respondents also left many questions blank. Since the survey was designed to assess how blueberry growers make decisions, I eliminated respondents who did not appear to be actively involved in the decision-making process. These individuals may own fields, but appeared not to know how their fields were managed. However, I did include these respondents in some analyses (as discussed below).

Three more individuals were excluded because they left many questions blank. Five growers (two conventional and three IPM) who hired a manager were left in the analysis because they seemed to have knowledge and input into how their fields were managed and answered the survey questions in depth.

Nine more growers were excluded because they did not clearly categorize themselves under the headings of IPM, Conventional/Traditional, Organic, and No Spray. Five did not select any category to describe their operation, and four growers selected boxes under both IPM and Conventional. Had there been more people who had left this area blank, or who had checked multiple boxes, I might have assigned them additional categories. However, because there were only four or five in each group, and because these nine individuals varied greatly in their alignment to the other four categories when analyzed, they were excluded to increase power in the analysis. A total of 100 surveys were considered for most of the analyses.

Statistical Analysis

All statistical analyses were conducted using the statistical software JMP (Anon. 2007). I conducted linear Pearson and Spearman's rho correlations to determine association between continuous and rank order variables. I also performed Analysis of Variance followed by Tukey's multiple comparison test to determine differences between categorical factors. I used Principle Component Analysis to ordinate all of the survey respondents based upon their responses, but eigenvectors did not explain enough of the variance in these data for this ordination technique to be of use. A comparison-wise error rate of alpha = 0.05 was used for all tests. I acknowledge that when conducting multiple statistical analyses at a comparison-wise error rate of alpha = 0.05, the experiment-wise error rate is greater than alpha = 0.05. Instead of using Bonferoni correction to adjust the comparison-wise error rates, I used a conservative and cautious approach when making conclusions and usually only considered effects that were highly significant ($P < 0.01$).

RESULTS AND DISCUSSION

Managers vs. Owners

The eleven respondents who do not manage the fields they own were excluded from the overall analyses. I included only respondents who could be considered "growers" and who were making decisions about blueberry-growing practices. I found that the 16 non-managers (11 of which were later excluded, five of which were included, in the overall analyses) differed in some regards when compared to the 95 respondents who do manage wild blueberry fields. Land owners who don't actively participate in field management are less likely to incorporate recommendations from the University of Maine Cooperative Extension ($F_{(1,112)}$=5.47; P=0.02), and are more highly influenced by media, such as newspaper articles, TV, or movies than blueberry field growers and managers ($F_{(1,112)}$=4.31; P=0.04). Non-managers are less concerned about stewardship of the land ($F_{(1,101)}$= 5.16; P=0.02), less concerned about helping to further scientific research ($F_{(1,98)}$=6.65; P=0.01), and more concerned about leaving land open and undeveloped ($F_{(1,101)}$=5.54; P=0.02) than managers. Non-managers were also older overall ($F_{(1,116)}$=14.38; P<0.01). Wild blueberries will grow naturally and can be maintained with minimal investment (Drummond et. al. 2009). Even though more intensive management does increase wild blueberry yields (Yarborough 2004), some growers may wish to maintain land as a natural blueberry landscape in order to keep it open and undeveloped. People who were once growers may also elect to

have their fields managed by someone else as they get older in order to keep the land open in order to maintain its value.

Management Style Categories

Survey data obtained from one-hundred **wild blueberry** growers were analyzed. Twelve growers considered themselves "Conventional", 64 "IPM", 13 "Organic", and 11 were "No-Spray." Each category was given a set of choices by which the growers could define what that category label meant to them. Eighty-Seven percent of the IPM growers defined "IPM" to mean that they scout and monitor fields for pests to determine when and where pesticides are needed. Of the 13 organic growers, eight said that no pesticides are applied to their land; five said that only organically approved pesticides are sprayed.

Ten of the 11 no-spray growers defined their category as "not organic certified but no chemicals are sprayed", however two no-spray growers noted their use of the herbicides, glyphosate, and sethoxydim, which seems to negate their "No-Spray" status. Some no-spray blueberry growers may not consider herbicides as "pesticides," as they are thought to be less toxic than insecticides and fungicides (D'Appollonio et. al. 2010), or because these growers may use such a small amount that they consider it minimal or not a significant part of their management. Also, many herbicides are applied only during the vegetative year, after the berries have been harvested, and some growers may consider this to be of minimal risk to humans. The eleventh no-spray grower checked the box marked "other," in the choices for how to describe the "no-spray" classification, and did not provide further explanation.

Conventional growers varied widely in a specific definition of their category. They were given choices such as, "I spray according to the calendar year" and, "I spray

according to when pesticide applicators are available." These growers checked multiple boxes under the Conventional heading. Of the twelve growers, only four said they sprayed according to the calendar year, five indicated that they sprayed according to when pesticide applicators were available, four said they spray, but try to use less, and two said they sometimes hire a contractor to spray for them.

The distinctions between IPM and Conventional and between Organic and no-spray are not definitive as there is overlap. I will discuss more about variation between self-defined grower groups later. I will also discuss whether it is fair to compare IPM blueberry growers with conventional, since conventional blueberry growers may not fit the definitions that have been historically associated with "conventional" growers of other crops.

Demographic Characteristics

Of the 100 respondents analyzed, 27 were from Washington Co., followed by nine from Hancock Co., six from Knox Co., and four from Penobscot Co. Waldo, Lincoln, and Franklin counties each had two respondents; Somerset, Aroostook, Cumberland, and Kennebec each had one grower. The rest left the county question blank. Eighty percent were male, and growers were evenly distributed in age, between 32 and 81. Ages, when arranged by management style from oldest to youngest were ranked: Conventional, IPM, No-Spray, Organic, but the differences in age were not significant by group ($F_{(3,96)}=0.11$; $P=0.95$). Likewise, there was no significant difference in education between grower groups. Age and education as they relate to the Diffusion of Innovations Theory will be discussed in the Results and Discussion section.

Half of the growers surveyed make less than 15% of their annual income from blueberries. Only 11 respondents reported that blueberries generate 90-100% of their income. Of these, one was conventional, and one was organic; the other nine were IPM. However, six of the 13 organic growers were full-time (46%) while 37% of IPM growers were full-time. Organic and IPM growers may rely more on blueberries for their annual income than no-spray and conventional growers ($F_{(3,89)}$=2.64; P=0.054), however more than 50% of each grower group earn income from a job other than blueberry growing (Table 1).

Growers were asked how many acres they harvest in a given year. To get an idea of total acreage managed, this number should be doubled, since blueberries are generally managed on a two-year pruning cycle. Half of all growers harvest under 20 acres per year, and three-fourths harvest under 50 acres. Six respondents reported harvesting over 500 acres per year, and three of those harvest over 1000 acres. I investigated farm size (in acres) as it relates to IPM practices. For these statistical analyses, I included only IPM and conventional growers, since many organic and no-spray growers either left these sections blank or wrote "N/A." IPM and conventional growers with more acres practiced ICM (χ^2 = 16.4; P<0.0001) and IPM (χ^2 = 23.4; P<0.0001) significantly less than those with fewer acres. Those with more acres also used perimeter sprays significantly less (χ^2= 5.3, P=0.02). These practices may take more effort and may be more difficult to maintain for managers of larger operations.

Growers were also asked if they had a partner in their blueberry operation. Forty percent farm with their spouse, 20% work with a relative, and 30% have no growing partner at all. Most operate under a sole ownership (74%), and some are organized as a

corporation (13%) or partnership (10%). One respondent was the manager for fields owned by the Passamaquoddy tribe.

Table 1. Farm size, experience, age, education and income by farm type. Groups with the same letter are not significantly different.

Averages	CVT n=12	IPM n=64	ORG n=13	NS n=11	p-value[a]	F-Ratio[a]
acres harvested (range) 1:under 5 acres; 2:6-20; 3:21-50; 4:51-100; 5:101-200; 6:201-500 7:500-1000; 8:over 1000 acres	mean: **2.0b** *(6-20 acres)* SD: 0.6	mean: **3.3a** *(21-50 acres)* SD: 1.72	mean: **2.0b** *(6-20 acres)* SD: 1.08	mean: **1.3b** *(< 5 acres)* SD: 0.47	<0.001	8.67 (3,89)
years growing (range) 1: under 5 years; 2: 5-10 years; 3: 11-20 years; 4: 21-40; 5: over 40 years.	mean: **3.8a[2]** SD: 1.11	mean: **3.7a[2]** SD: 1.19	mean: **2.8b[2]** SD: 1.34	mean: **2.8b[2]** SD: 1.17	0.016	3.59 (3,99)
% income from bb	mean: 14.67 SD: 28.16	mean: 34.43 SD: 35.42	mean: 33.50 SD: 34.86	mean: 6.00 SD: 7.03	0.054	2.64 (3,89)
age	mean: 60.75 SD: 8.36	mean: 58.75 SD: 11.96	mean: 58.50 SD: 11.67	mean: 59.10 SD: 10.58	ns[1]	
education 2: graduated high school; 3: attended college 4: completed Bachelor's; 5: some grad school; 6: grad degree	mean: 3.58 SD: 1.44	mean: 3.86 SD: 1.48	mean: 3.62 SD: 1.61	mean: 4.18 SD: 1.66	ns	
full-time growers (n)	0	24	6	0	ns[5]	

[1]ns indicates no significant difference and numbers in parentheses indicate degrees of freedom for ANOVA; [2]Difference detected with student's T-test. All others: Tukey's; [3]Chi-square between Organic and No-Spray; [4]Chi-square between IPM and Conventional; [5]Chi-square between IPM and Organic.

There were significant differences between growers of different management styles when it came to income from wild blueberries, part- or full-time status, years spent as a grower, and acreage. no-spray and organic growers have been growing for less time than IPM and conventional ($F_{(3,99)}$=3.59; P=0.016). The data on income were highly varied. Three growers noted a loss from blueberries, and 13 indicated that blueberries contribute 0% to their yearly income. There is no difference between the percent of annual income that IPM and organic growers earn from blueberries annually, but both groups may depend more on blueberries for their income than growers who practice No-Spray. IPM growers tend to harvest more acres than the other three groups. The average blueberry grower is about sixty years old, and has either completed a Bachelors degree or has attended some college. But there were no significant differences found between grower groups in age or education (Table 1). As might be expected, those with more

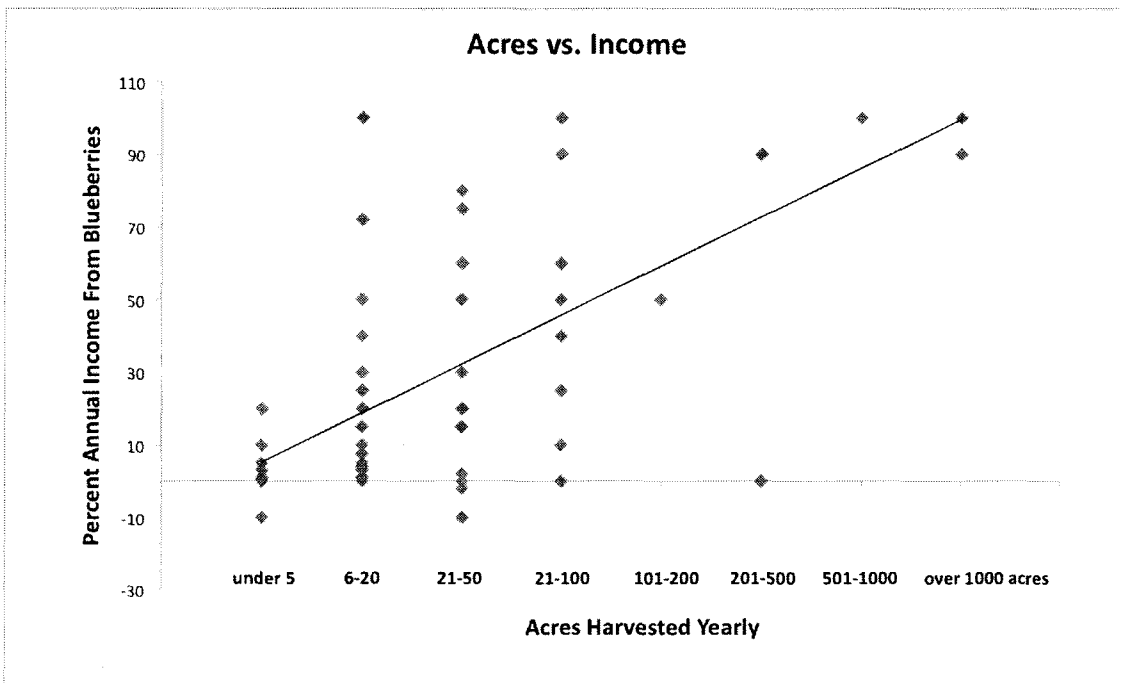

Figure 1. The relationship between acres harvested per year and the percent of annual income that comes from blueberries. Negative income indicates lost income on blueberries. r=0.66; P<0.0001(correlation performed upon the rank of acres harvested).

acreage tend to earn a higher percentage of their annual income directly from wild blueberries (Figure 1).

Production Practices

Pruning

All growers indicated that they prune their fields, and many indicated use of multiple methods (Table 2). Straw burning is still practiced by about 1/3 of growers from each category. A greater percentage of conventional and IPM than organic and no-spray growers use oil to burn their fields. Most growers, independent of category, prune at least some of their fields by mowing. Eighty-seven percent of all growers prune some or all of their fields this way. Ninety-three percent of growers responding to the survey indicated that they prune individual fields every other year. The remaining respondents prune individual fields less often, every 3 to 4 years, despite there being University of Maine

Table 2. Pruning practices by grower category. Total counts by category are given, followed by total percentages of each group.

	straw burn	oil burn	mow	every other year
CVT	4	7	10	12
n=12	33%	58%	83%	100%
IPM	22	34	58	62
n=64	34%	53%	91%	97%
NS	3	1	9	9
n=11	30%	10%	90%	90%
ORG	4	2	10	10
n=13	31%	15%	77%	77%
TOTAL:	33	44	87	93

[1]Abbreviations: CVT=Conventional; IPM=integrated pest management; NS=No-Spray; ORG=Organic.

Cooperative Extension information showing that this is not an optimal economic production practice (DeGomez 1998).

Weeds

Weeds are a considerable problem for wild blueberry growers, and nearly all growers practice weed management. A high percentage of conventional and IPM growers use fertilizers and herbicides (Table 3). Fewer of the no-spray and organic growers use

Table 3. Soil fertility and weed control practices by grower group.

	fertilizer use	leaf samples for fertility analysis	herbicide use	sulfur use	cut weeds
CVT	10 83%	4 33%	9 75%	4 33%	10 83%
IPM	57 89%	40 63%	62 97%	31 48%	52 81%
NS	5 50%	1 10%	3 30%	3 30%	10 91%
ORG	2 15%	1 8%	2 15%	11 85%	11 85%
TOTAL:	74	46	76	49	83

these products, but no-spray growers tend to use fertilizer more than organic growers. Eighty-five percent of organic growers do use chemical soil amendment for weed management, i.e. adding sulfur to decrease the acidity of their fields and to create a sub-optimal environment for the growth of grasses and other weeds (Yarborough 2001). The two organic growers who did not use sulfur, use organic herbicides instead and were among the five organic growers who spray certified organic pesticides/herbicides. Integrated Crop Management is a production method that includes pest management but also includes fertility strategies in which growers take leaf samples to determine if and

when fertilizer application is necessary. Forty-six growers total, 40 of which are IPM growers, take leaf samples for this purpose.

Pollination

Pollination is extremely important for success in most fruit crops (Delaplane and Mayer 2000). An integrated pollination strategy might involve renting honeybees, purchasing commercial bumblebee hives (Stubbs et al. 2002), and conserving native bees by providing them with habitat and alternate forage and by spraying only during times of day when bees are less active. The use of native bees, including bumble bee purchase, is a relatively recent strategy put forth by the Cooperative Extension. Adoption of innovations related to native bees might therefore serve as a proxy to identify early adopters. This will be reintroduced later, when we discuss Diffusion of Innovations Theory.

Seventy-nine percent of all wild blueberry growers purchase or rent commercially-available bees (Table 4). Conventional, IPM, and no-spray growers are more likely to use honeybees over bumblebees, but a difference between IPM and conventional growers and between organic and no-spray growers can be seen in the adoption of bumble bees: Seventeen IPM, versus only one conventional grower used commercial bumblebees, and four organic growers versus zero no-spray growers have adopted this technology. Similar patterns will be discussed below in the encouragement of other native bees (Table 5).

A higher percentage of organic growers own their own honeybee hives, while the other three grower categories tend to rent honeybee hives. IPM and conventional growers had the highest density of hives per acre, indicative of more intense management.

Organic growers may use fewer honeybee hives and may be more likely to own hives than rent because of the expense. Organic farms are also smaller, on average, than IPM, and smaller farms tend to have more edge habitat than larger farms, where native pollinators nest (Drummond and Stubbs 2003). Importation of large numbers of bees may therefore not be as necessary on smaller farms with more edge habitat. More research should be conducted on whether use of pesticides increases the need for imported pollinators.

Table 4. Use of commercially purchased bees and hive ownership by grower group.

	use some type of bee	use honey bee hives	purchase bumble bees	own honeybee hives	average # of hives per acre
CVT	10	9	1	0	1.83
n=12	83%	75%	8%	0%	
IPM	56	55	17	4	2.02
n=64	88%	86%	27%	6%	
NS	5	5	0	1	1
n=11	50%	50%	0%	10%	
ORG	8	5	4	4	0.75
n=13	62%	38%	31%	31%	
TOTAL:	79	74	22	9	1.79

Specific practices recommended by the University of Maine Cooperative Extension to encourage wild, native bees include: hanging nest boxes, leaving standing dead wood for native bees to inhabit, allowing other flowers to grow nearby which provide alternate food during times when blueberry is not flowering, and using insecticides that are less harmful to pollinators (Drummond and Stubbs 2003). The most common methods of enhancement employed by the surveyed growers include: leaving

standing deadwood and providing alternate forage, especially among no-spray and organic growers (Table 5).

Both IPM and organic growers are more likely than conventional and no-spray, on average, to purchase bumblebee hives and to encourage native pollinators on their land. This may serve as evidence that IPM growers can be considered early adop ters among IPM and conventional growers, and organic can be considered early adopters among organic and no-spray growers. Conventional and no-spray growers might be thought of as "laggards," or people who are slower to adopt new technology. We will also see, later on, that these two groups might also be slower to adopt new technology because they are less involved with "change agents" (i.e. the extension).

Table 5. Methods in attempt to enhance native bee populations, by grower group

	Yes, attempts	Hangs nesting blocks	Leaves dead trees	Uses less harmful pesticides	Uses no pesticides	Provides alternate forage	other
CVT	5	3	3	2	1	3	0
n=12	42%	25%	25%	17%	8%	25%	0%
IPM	54	17	36	32	7	28	2
n=64	84%	27%	56%	50%	11%	44%	3%
NS	7	1	7	0	8	7	0
n=11	64%	9%	64%	0%	73%	64%	0%
ORG	11	1	9	2	10	10	0
n=13	85%	8%	69%	15%	77%	77%	0%
TOTAL	77	22	55	36	26	48	2

Four no-spray and organic growers and three IPM growers noted the adequate abundance of native pollinators on their land. Nine IPM growers noted other things they do to encourage native bees, such as planting "bee pastures" or, in the case of one grower, placing old mattresses around the edge of his field for bees to nest in. One no-spray grower said he plants extra flowering bushes along the edge of his field, and one organic grower said she leaves straw bales near bumblebee quads for the queens to occupy over winter. Fewer conventional growers might attempt to encourage native bees, as fewer of them attend University of Maine Cooperative Extension grower meetings where these methods are promoted and described (attendance at meetings will be discussed below).

It is possible that honeybees are imported by a greater number of IPM and conventional growers because their greater use of pesticides reduces native bee populations. This is speculative, but it is known that pesticides can kill beneficial, native pollinators as well as target organisms (Drummond and Stubbs 2003; Devillers et. al. 2003; Valdovinos-Nuunez et. al. 2009). Significant linear correlations were found between the number of hives per acre that growers stocked their fields with and the number of pesticides they used ($r=0.353$; $P<0.01$) and with the total number of pesticide applications made ($r=0.328$; $P<0.01$). It is possible that growers who use more pesticide tend to use more honeybee hives because they manage more intensively and introduce more pollinators to improve berry production. Their fields also tend to be larger and might therefore have less edge habitat, where native pollinators live. But some farmers may not realize that insecticides kill beneficial insects, including pollinators, as well as he targeted insect pests. Future studies should be conducted to determine whether use of

pesticides creates a direct need for imported pollinators.

Pesticide Use

Growers who use pesticides are more likely to be conventional or IPM, while no-spray and organic growers tend not to use these management tools, even though there are a few organically approved pesticides (D'Appollonio, 2010). Growers who spray "restricted use" pesticides which are usually more toxic, and/or who spray commercially for other growers, are required by law to have a Maine pesticide applicator's license. Three-fourths of conventional and IPM growers have this license, while organic and no-spray growers tend, on average, not to (Table 6). However, four organic and three no-spray growers have had this license for three years or more. Some growers in these two categories may have recently switched to organic or no-spray production, but still possess a license even if not used. One grower who labeled himself Organic implied that he managed multiple fields, some of which were organic and some of which some were not.

Table 6. Grower group by use of pesticides to control pests, agreement with statements about beneficial insects, and pesticide license status.

	Use pesticides	Believe insect predators help control insect pests	Believe more research should be done on insect predators	Possess Maine pesticide license
CVT	10	8	9	4
n=12	83%	67%	75%	33%
IPM	47	44	52	53
n=64	73%	69%	81%	83%
NS	0	8	10	3
n=11	0%	80%	100%	27%
ORG	3	12	11	4
n=13	23%	92%	85%	31%
TOTAL	60[1]	72[1]	82[1]	64

[1]Total counts

Growers were asked in the survey, whether they believe insect predators, such as ants and spiders, help control insect pests. University of Maine Cooperative Extension scientists have conducted studies in which pest insects decreased in the presence of certain insect predators, such as ants and spiders (Drummond et al. 2009). Eighty percent of No–Spray growers believe in the effectiveness of insect predators, as do all organic growers, except possibly for one grower who left this question blank. A lower percentage of conventional (67%) and IPM (69%) growers believe this. One explanation for this is that organic growers spray fewer and less pesticides and are probably more likely to have observed the beneficial effects of insect interactions. Growers who manage their land more intensely with pesticides may not have the chance to see the benefits of insect predators. Conventional growers were also not as likely as the other growers to believe that more research on predatory insects should be conducted, possibly because conventional growers attend University of Maine Cooperative Extension meetings less, where this research on beneficial insects is discussed. Growers might benefit by leaving a

small, secluded area of their field untreated (Pedigo and Rice 2006). This would allow them to compare for themselves any differences between treated and untreated fields in predator insect effects and necessity for imported pollination.

When applying pesticides, farmers must keep detailed records by law. This includes noting specific environmental factors present at the time of application. Growers were asked whether they note nearby water sources and wind direction before spraying, and whether they refrain from spraying during certain weather conditions, as required by Maine state law (Table 7). No grower answered "no" to this question, but a small number left it blank, two from the Conventional category and two from IPM. One of the conventional growers does not spray any pesticides at all and had a toxicity rating of zero, the other indicated that he has someone else spray for him. One of the IPM growers said that he does not spray, the other said she is new to the blueberry growing business, and may still be deciding how she wants to manage her fields.

Table 7. Growers who follow spray laws and their reasons for doing so.

	follow spray laws	have to	want to	concern for water table	neighbors might complain
CVT	10	6	8	4	6
n=12	83%	50%	67%	33%	50%
IPM	62	51	55	46	38
n=64	97%	80%	86%	72%	59%
NS	3	2	2	2	1
n=11	30%	20%	20%	20%	10%
ORG	5	4	3	3	1
n=13	38%	31%	23%	23%	8%
TOTAL	80	63	68	55	46

The organic and no-spray growers may have wished for a "Not Applicable" category. Some of these growers may have left the question blank not because of failure

to pay attention to those factors, but because they do not spray at all. Fourteen of the no-spray and organic growers wrote in "N/A" themselves. Three no-spray growers indicated that they do note environmental conditions before they spray, which is curious because it implies that they spray. Two of these growers specifically noted that they spray the herbicides sethoxydim and glyphosate but not "pesticides." They might define pesticides as insecticides only. The other of these growers is just starting out and does not spray pesticides. He does not have a Maine pesticide applicators license, but applies sulfur and organic fertilizer. Perhaps he notes the environmental conditions when applying sulfur or fertilizer, or he wished to indicate that he *would* note those factors if he *were* to spray.

Growers were also asked their reasons for noting or not noting the environmental conditions before spraying, and they could check multiple boxes. The most cited reason for following the laws was because they have to and because they want to have less of an impact on the environment. A greater percentage of IPM growers than conventional were concerned about the water table. Conventional growers were more worried about relations with neighbors than they were about the water table. If there were any growers who do not follow these laws, they did not indicate so on the survey.

Meeting Attendance

IPM growers were most likely of all the groups to attend University of Maine Cooperative Extension grower meetings, workshops, and events regularly (84%, followed by organic growers (54%), conventional (42%), and then no-spray (30%)). IPM growers stated that they attend because they wish to earn credits towards their pesticide applicator's license (Table 8). But they also cited curiosity (learning new things) and convening with other growers as reasons for attendance. Fewer organic growers attend

Table 8. Grower attendance in Cooperative Extension workshops and field meetings and reasons for attending or not attending, by grower group.

	Attends regularly	To earn credits	To learn things	To convene with others	Attends for another reason	Does not attend: too far	Does not attend: not useful
CVT	5	4	3	2	0	5	0
	42%	33%	25%	17%	0%	42%	0%
IPM	54	51	46	40	1	5	0
	84%	80%	72%	63%	2%	8%	0%
NS	3	3	2	2	1	4	2
	30%	30%	20%	20%	10%	40%	20%
ORG	7	4	6	4	0	3	0
	54%	31%	46%	31%	0%	23%	0%
total	69	62	57	48	2	17	2

than IPM, but they attend for the same reasons. About 42% of the conventional and 40% or the no-spray growers said they live too far from where meetings are held. Only two growers did not find the meetings useful and they were no-spray growers. Sixty percent of the no-spray growers do not attend Extension meetings regularly. This is perhaps because they are low-input growers and the University of Maine Cooperative Extension faculty may tend to address active management techniques. In regards to the Diffusion of Innovations Theory, this is evidence that no-spray and conventional growers are less in contact with change agents and with avenues of influence outside of their own communities. They may therefore be slower to learn of and to adopt new technology. Growers who attend the University of Maine Cooperative Extension meetings regularly (IPM and organic) are also the same grower categories that depend on wild blueberries for a considerable part of their income. IPM growers earn an average of 34.4% of their income from blueberries, while organic growers earn an average of 33.5%. These two groups may be more dependent on blueberries for their annual income than the other two

groups, and thus more interested in learning of new, effective techniques from the Extension.

Toxicity Ratings

Toxicity rating will increase if a farmer uses a highly toxic pesticide, or if they use a less toxic pesticide, but use it often. I found toxicity rating to be positively correlated with the number of different pesticides used ($r=0.78$; $P<0.0001$) and with the total number of applications made of all pesticides ($r=0.82$; $p<0.0001$). Only one grower applied two different pesticides three times each. Most growers who used pesticides applied individual pesticides only once per growing season. Propiconazole, a fungicide that scored a three on the index, and phosmet, an insecticide with an 11 on the index, were two exceptions of note. Propiconazole was applied by 26 growers, two of whom were conventional, the rest IPM growers. Fifteen applied it twice per year, one person applied it three times, and the remaining 10 applied it once per year. Phosmet, used by 34 IPM and conventional growers, is one of the more toxic pesticides used in Maine lowbush blueberry (classified as a moderately toxic insecticide in terms of acute toxicity to humans). Eight growers (all IPM) used phosmet twice, while 26 used it once per growing season. One grower had a toxicity rating of 18 because he used azinophos-methyl, a highly toxic insecticide to humans which can no longer be purchased for use in lowbush blueberry, but for which existing supplies may still be legally used. This grower indicated that he used no other pesticides (including herbicides) on his blueberries, but his use of this one caused his level to increase dramatically. He was the exception for this scenario. In the majority of cases, toxicity rating was a reflection of the number of *different* pesticides used and the number of applications per year, combined with the toxicity index of each pesticide used.

But a few qualifiers are in order for the toxicity rating system. The system is extremely superficial. For one thing, it is based solely on the 2010 Maine pesticides chart. It also lacks a number of considerations. It does not take into account the size of the farm, but assumes treatments are done per acre, which means that a "toxicity rating" does not consider farmers who apply a pesticide only to a portion of their field versus those who apply it to the entire field. This toxicity system also does not consider the breakdown rate of each pesticide in the environment. For example, two pesticides could each have the same toxicity levels, but different modes of breakdown in the environment. One might take three days to completely disappear, the other might take longer. The toxicity ratings here were calculated with the information available (both in the literature and from the growers), and with the time allowed. More complete data on the pesticides and their use should be obtained for a more accurate picture of toxicity as it relates to other factors. One should keep this in mind while reading the correlations to toxicity ratings, below.

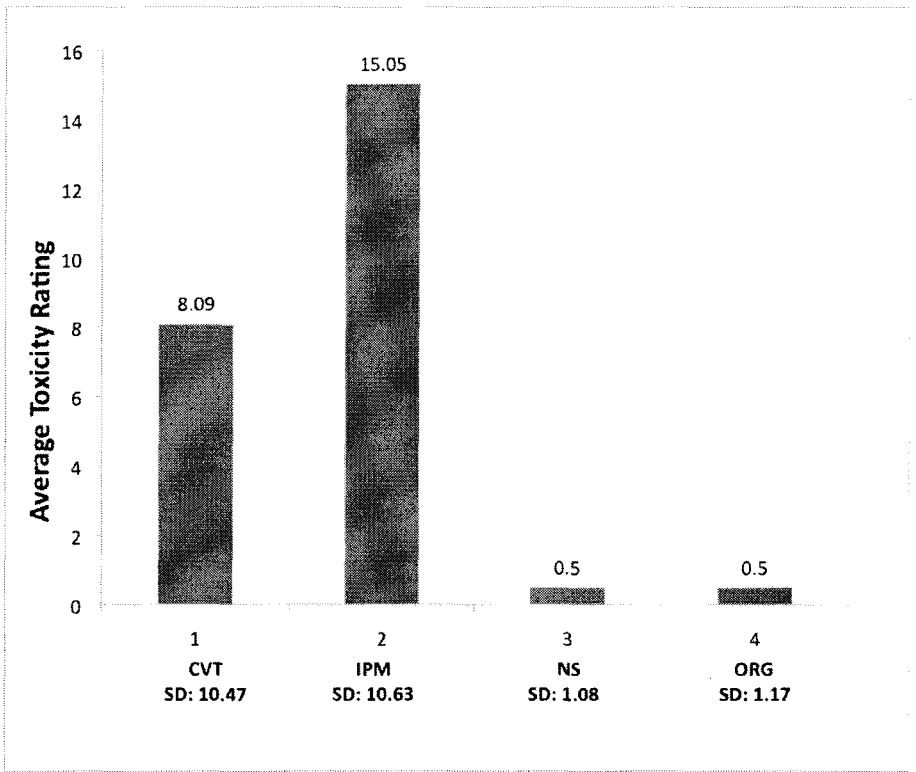

Figure 2. Farm type and average pesticide toxicity rating. $F_{(3,88)}=12.05$; $P < 0.0001$.

Toxicity rating ranged from zero to 40 and varied according to farm type (Figure 2). IPM growers had significantly higher ratings than organic and no-spray ($F_{(3,88)}$=12.05; P<0.0001). By sight (Figure 2), it appears that conventional growers had toxicity rating lower than IPM growers, a surprise given that major goals of IPM include reducing pesticide use. However, toxicity ratings of IPM and conventional growers were not significantly different from each other, and both groups varied widely in their ratings. I will discuss later on whether it even makes sense to compare IPM growers to conventional, since "conventional" may have a different meaning when applied to blueberry growers as it does when applied to other crops. Three conventional respondents had a rating of zero, and four were between 13 and 32; One did not fill this section out. IPM growers also varied in toxicity rating (mean: 15.05; SD: 10.63). No IPM grower had a rating of zero, but fourteen had ratings of less than 6; Forty were between 6 and 40; and eight of the IPM growers did not fill this section out. The highest rating among organic growers was 3. Nine no-spray growers had rating of zero, and two used the herbicides glyphosate and/or sethoxydim, which gave them ratings of 2 and 3. These two individuals sprayed herbicides, but may consider themselves no-spray because they did not spray insecticides or fungicides. Increased toxicity rating was positively associated with income from blueberries, years spent as a grower, and acres harvested each year (Figures 3-5). There was no correlation between toxicity rating and age (P= 0.38) or education (P=0.57).

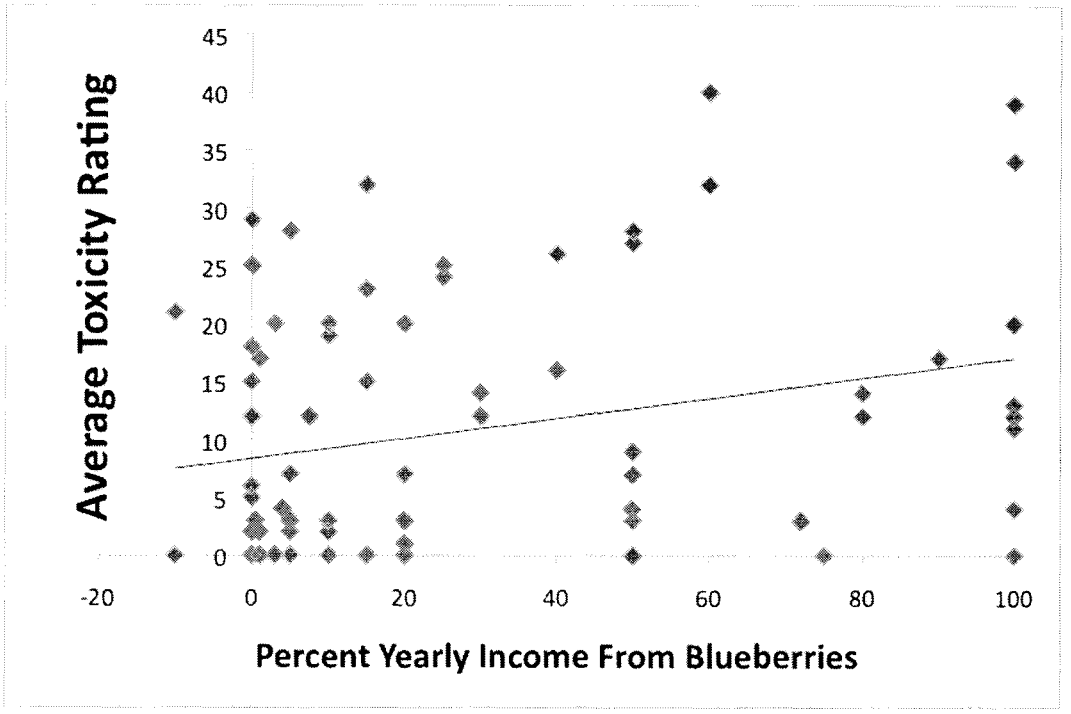

Figure 3. The relationship between percent of annual income coming from blueberries for individual growers and the toxicity rating for their farm. Negative values indicate lost income. $r = 0.328$; $P < 0.01$

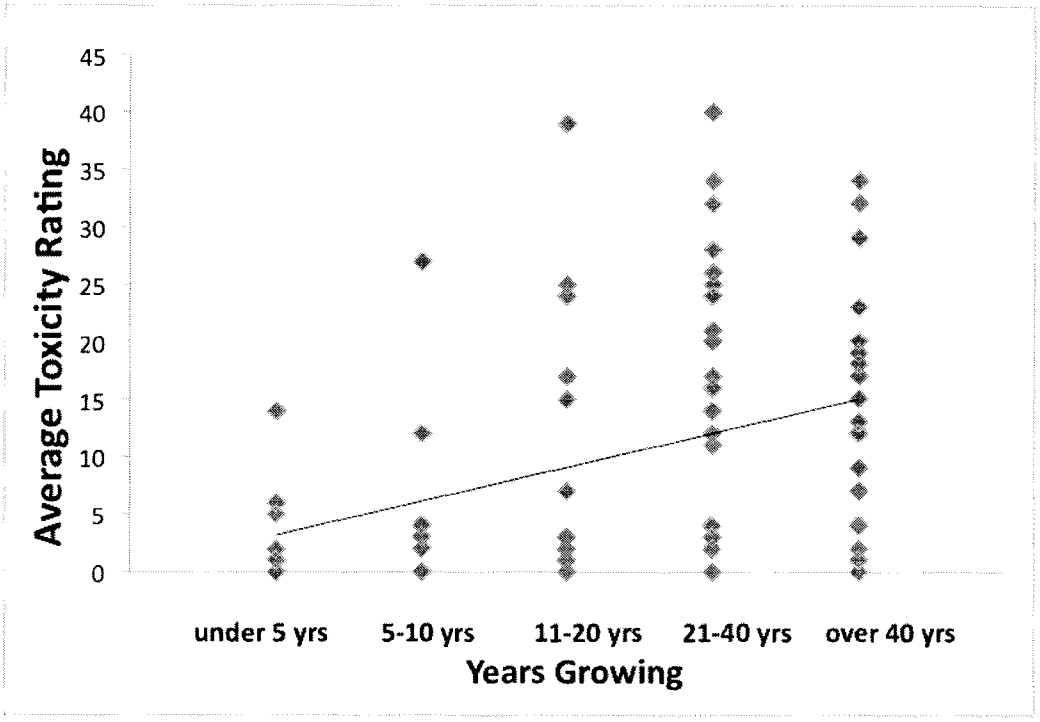

Figure 4. The relationship between years spent growing blueberries by a grower and toxicity rating of pesticides used by that grower. $r=0.3$; $P<0.01$

Those who have spent more years growing wild blueberries have a higher toxicity rating ($r=0.3$; $P<0.01$), yet toxicity cannot be predicted by age. This could mean either that growers begin to use more pesticides the more years they spend as growers, or that inexperienced growers are not necessarily younger, and/or that new growers are deciding to use fewer pesticides.

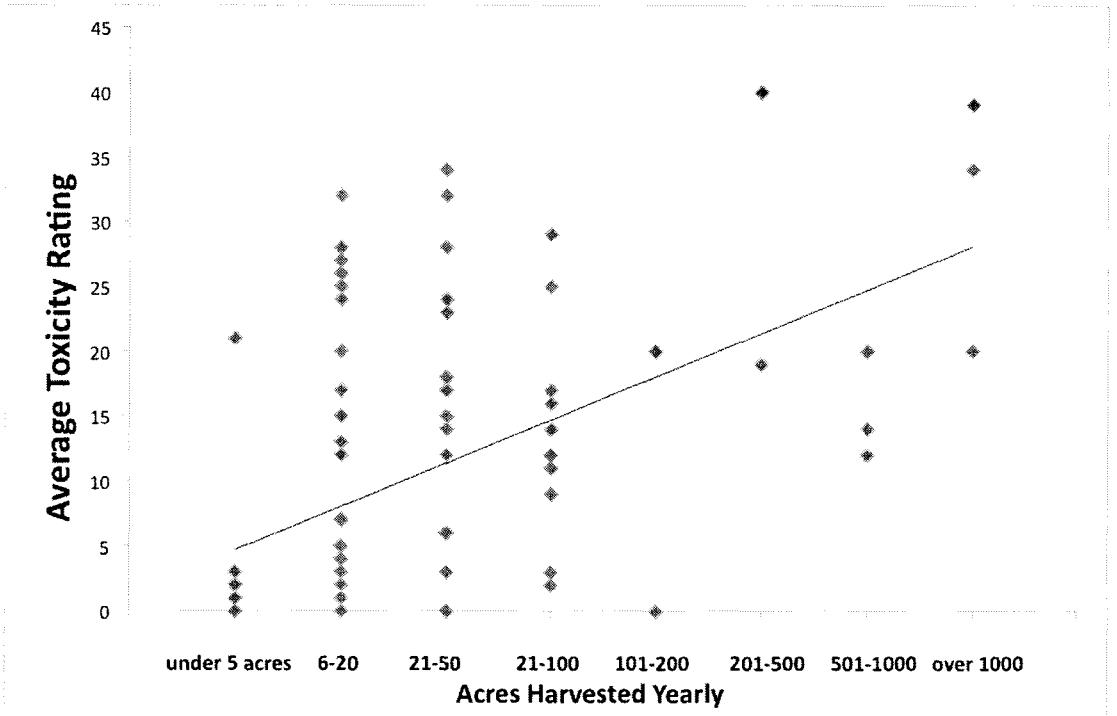

Figure 5. The relationship between acres harvested yearly by each grower and toxicity rating. r =0.44; P<0.0001.

Management Intensity

It may be helpful to synthesize the data into a summary of the management methods practiced by each type of blueberry grower. Table 9 gives a visualization of the data, organized by practices of the typical grower within each group. In E.M. Rogers' Diffusion of Innovations Theory, a practice is considered to be moving towards widespread adoption once more than 15-20% of the community adopts it. Here, just to be sure, I used 50% as a cutoff point to indicate whether a practice was considered characteristic of the farm group. There were some practices that were characteristic of all growers, independent of farm type category: Fifty percent or more from each group prune

their fields by mowing, prune every other year, use some type of bee for pollination, and earn income from another job aside from blueberry management. It is interesting that a higher percentage of organic (46%) than IPM (37.5%) grow blueberries full-time, and that many organic growers may grow blueberries full-time *and* earn income elsewhere.

Some similarities and differences among groups might be of interest. No-Spray are similar to organic growers in their toxicity rating and practices, however, there seem to be some subtle differences between the two groups as well. The typical no-spray grower uses fertilizer (organic and non-organic) but not sulfur, whereas the typical organic grower uses sulfur, but not fertilizer. One possible explanation for this is that more organic growers than no-spray growers attend University of Maine Cooperative Extension meetings, where sulfur is recommended, so sulfur may be the more salient option for them. Organic growers might also be more wary of using fertilizer because it promotes the growth of weeds and they are not permitted by MOFGA to use non-organically OMRI-approved herbicides. Another difference between the two is that the

Table 9. Management Intensity of a Typical Grower, by Group[1]

Conventional	IPM	Organic	No-Spray	All Growers
• Prunes by oil burn • Prunes by mowing • Uses fertilizer • Uses herbicides	• Prunes by oil burn • Prunes by mowing • Uses fertilizer • Uses herbicides	• Prunes by mowing • Uses sulfur	• Prunes by mowing • Uses fertilizer	• Prune by mowing • Prune every other year
• Rents honeybees • Uses more than 1 hive per acre • Uses pesticides	• Rents honeybees • Uses more than 1 hive per acre • Uses pesticides • Has pesticide license • Harvests more than 21 acres average • Makes more than 15% of income from berries. • Toxicity rating > 14	• Uses some type of bee	• Rents honeybees	• Use some type of bee
• Earns income from another job	• Earns income from another job	• Earns income from another job	• Earns income from another job	• Earn income from another job

[1]A characteristic was added under the grower group if more than 50% of those growers maintained that practice.

organic grower is more likely than the no-spray to grow full-time and to make more of their income from blueberries. No-Spray growers might be thought of as lower input organic growers who are not officially certified by MOFGA, and who do not depend on wild blueberries for as much of their income.

Conventional and IPM growers are likewise similar, save for a few differences. The typical IPM grower tends to harvest more acres, make more of their income from blueberries, and have a higher toxicity rating than the conventional grower. IPM growers

also use sulfur while conventional do not. IPM growers might be considered higher input conventional growers, who manage more intensively and who depend on blueberries for more of their income. Conventional and no-spray growers might also be thought of as subcategories of each IPM and Organic, whose main difference is that they do not attend meetings as regularly and do not earn as much their income from wild blueberries. More on this will be discussed in the Discussion section.

Grower Priorities

There were only a few significant differences between growers of different management styles and factors they considered important for their production (Table 10). Participants were asked to rank ten factors in order of personal importance, with 1 as the most important, and 10 as the least important. Many did not follow the directions completely, and entered the same number multiple times, and 13 out of 100 growers left this section blank. Some expressed frustration at having to place a rank on these factors,

Table 10. Factors of Personal Importance by Farm Type. Percentages show growers who placed the factor among their top three, out of the 10 choices. Differences between grower groups were calculated using Tukey's multiple comparisons test. Farm types marked by the same letter are not significantly different, and rows with no letters refer to factors where there were no significant differences by farm type.

Factor:	CVT n=12	IPM n=64	ORG n=13	NS n=11	of all growers:
making a profit	31%	57%	57%	46%	58%
maintaining land value	50%	50%	43%	46%	54%
providing healthy food for public	19%	43%	71%	46%	48%
continuing my family's legacy	**44%b**	**37%b**	**14%a**	**31%a**	38%
spending time outdoors	38%	29%	29%	31%	34%
being a steward of the environment	13%	28%	57%	38%	34%
keeping land open/undeveloped	13%	28%	29%	38%	33%
being a part of ME's blueberry culture	6%	24%	14%	15%	21%
helping to further scientific research	13%	13%	21%	38%	19%
maintaining community relations	13%	18%	14%	15%	18%

saying that all were important to them, and no one aspect could be placed above others in the whole farming operation. Direct quotes include: "*Very hard to rank since all are interconnected.*" And, "*Hard to use a number only once.*" For the most part, the factors that a farmer considers important cannot be predicted by farm type, but there were some patterns worth mentioning.

"Maintaining the value of the land" and "making a profit" ranked high on everyone's list, no matter the grower category, and most growers placed community, culture, and scientific research at the bottom of their priorities. The only significant difference between grower groups was that IPM and conventional growers are more concerned about continuing their family's legacy than organic and no-spray growers ($F_{(3,79)}$=3.04; P=0.03). The survey suggests that IPM growers have been growing blueberries in their family for more generations than organic growers (mean IPM vs. mean organic, $F_{(3,94)}$=3.14; P=0.02).When the categories are combined, however, so that Conventional is together with IPM, and Organic is together with No-Spray, maintaining the value of the land becomes significantly more important to IPM/CVT growers than to ORG/NS ($F_{(1,84)}$=5.15; P=0.02).

Growers were allowed to add their own comments to this section if they chose. Most left the extra space blank, but a few growers left comments. One organic grower noted: *"Lessening input of all pesticides is key-- we are all stewards, not owners, of the land. Educating conventional growers towards this mind-set is crucial."* Another organic grower added, *"Practicing my ideas without supervision"* and, *"Independence in land management"* to the list of important factors; Three IPM growers each noted, *"I feel good about making a living wage while being productive."*; *"I take pride in being part of*

the Blueberry Industry and being an American Farmer."; and, *"Providing a safe work environment for us and those who help during the harvest."* One no-spray grower added, *"Supporting the small farm... growers who have been 'shut out' by large companies"* as important to their operation.

There were no significant effects when these personal beliefs were considered as a function of grower age or acres farmed. When analyzed in regards to income, those who earn a higher percentage of their income from blueberries may place more importance on maintaining the value of their land ($r=0.22$; $P=0.05$). Similarly, growers who have been growing blueberries for longer rate family higher on their scale of importance ($r=0.234$; $P=0.03$).

There were some interesting correlations to note between grower priorities and education level. One might expect those with less education to have entered the blueberry growing business earlier in life, or those for whom growing has been in the family for many generations to have entered directly into it after high school, but this does not seem to be the case. There were no significant correlations between education and years growing ($r = 0.046$; $P = 0.64$) nor the number of generations farming ($r = 0.039$; $P = 0.71$). One might also expect people with more education to be more likely to have jobs outside of blueberry growing, and that growing for them is more of a hobby than something to depend on. But this does not seem to be the case either, as there were no significant correlations between education and part- or full-time status, or between education and whether or not the grower made income from another job. It was also difficult to determine whether growers with growing partners should be analyzed according to the highest level of education achieved between them, or whether the

education level of only the respondent should be taken into account. Some teams may be making decisions together and influencing each other, while others may have one member making the majority of the management decisions. I analyzed the data both ways and found no new correlations.

When education was measured directly against **grower priorities**, the outcome was curious. It appeared that those with more education valued factors such as "furthering scientific research," and "keeping land open and undeveloped" significantly less than those with less education. However, this was found to be a case of Simpson's paradox (Malinas and Bigalow 2009): The outcome was different when the data were blocked first by management style, and *then* analyzed for education level. I analyzed the education levels of the respondents, and grouped their priorities according to farm type. Among IPM growers, those with less education prioritized furthering scientific research ($r=0.422$; $P=0.002$), keeping land open and undeveloped ($r=0.287$; $P=0.04$), and maintaining community relations ($r=0.401$; $P=0.004$) significantly *higher* than IPM growers with more education. Among organic growers, those with more education prioritized spending time outdoors ($r= -0.622$; $P=0.04$) and being a steward of the environment ($r=-0.612$; $P=0.04$) significantly *higher* than organic growers with less education. It is interesting that there were no significant differences in priorities between growers of different farm types (save for "family legacy") and no significant differences between grower groups in terms of education level, yet when considered within each grower group, some priorities can be correlated to level of education.

Opinions About Pesticide Safety

One question on the survey attempted to gauge growers' belief that new pesticides will always be available. Another was aimed at understanding growers' beliefs about the safety of legal pesticides (Table 11). IPM growers tended to agree more with the statement, "Scientists will be able to research new pesticides when insects become resistant to old ones" than organic and no-spray growers ($F_{(3,92)}$= 6.17; P<0.01). IPM growers also tended to agree, significantly more than organic and no-spray growers, that legal pesticides wouldn't be approved by the Maine Board of Pesticide Control unless they were safe ($F_{(3,94)}$=9.1; P<0.01). One IPM grower wrote: "*Safe use of approved pesticides depends on applicator's education and experience.*" Conventional growers could be distinguished from no-spray growers in the first question and from organic growers in the second question. The differences became even stronger when Conventional and IPM were combined into one group, and no-spray and organic were combined into another group, with the CVT/IPM having more confidence in scientists' research ability ($F_{(1,91)}$=20.25; P<.0001), and more confidence in the safety of legal pesticides than ORG/NS growers ($F_{(1,93)}$=23.68); P<.0001).

Table 11. Opinions About Pesticide Safety by Farm Type. Growers rated their opinions according to: 1= strongly disagree; 2= slightly disagree; 3:= neutral; 4: slightly agree; and 5= strongly agree. Farm types not followed by the same letter are significantly different.

	CVT	IPM	ORG	NS	
agreement level:	3.91ab	3.85a	2.7bc	2.55c	"Scientists will be able to research new pesticides when insects become resistant to old ones."
SD:	0.944	1.046	1.418	1.695	
agreement level:	3.33ab	3.27a	1.42c	2.09bc	"Legal pesticides must be safe since they were approved by the pesticide board."
SD:	1.073	1.339	0.996	1.300	

It is difficult to tell whether growers who use more pesticides do so because they have more confidence in their safety, or whether they have more confidence in the pesticides' safety because they use them. It is possible that those who use more pesticides understand more about how they work, since they are required to in order to maintain their pesticide applicators license. Alternatively, members of the ORG/NS groups may purposely seek out information on the detriments of pesticides, and may be more aware of their ill effects or of all that is still unknown about their long-term effects.

Opinions about research and pesticide safety could not be predicted by any of the following: education, age, years growing, or income. However, those with more acres in wild blueberries have more confidence in the safety of legal pesticides than those with less land ($r=0.217$; $P=0.03$) and, as previously discussed, those with more acres also have a higher toxicity rating and make more of their income from blueberries. They may have more confidence in the safety of legal pesticides simply because they use them more and depend on them more for their livelihood.

Growers were also asked their opinions about the University of Maine Cooperative Extension. The majority of all growers, regardless of management style or

any other factor, noted positive interactions with Extension and acknowledged the benefits derived from the organization. As a community, the growers were welcoming and receptive to input from extension faculty and agents.

Influences

Growers were asked to rate the factors that were most influential in causing them to change their practices or to learn new information (Table 12). A rating of 5 indicated a factor was highly influential, while 1 indicated no influence at all. A rating of 3 indicated a neutral feeling towards the factor's influence. Growers overall were most influenced by recommendations from the Extension, including factsheets and workshops, and least influenced by pressure from agricultural/industrial companies, and media, such as newspapers and television. Growers who practice IPM were significantly more influenced by the Cooperative Extension than conventional, but not more than organic growers.

Other correlations are also of note. Respondents who have been growing blueberries longer are weakly associated with being less influenced by blueberry grower websites ($r=0.209$; $P=0.056$) and more influenced by University of Maine Cooperative Extension factsheets ($r=0.202$; $P=0.05$). Growers with more acres are less influenced by the media ($r=0.216$; $P=0.03$), and those who depend on blueberries for more of their income are more highly influenced by demonstration plots than those who depend on them for less ($r=0.247$; $P=0.03$). Older growers are more strongly influenced by Extension workshops ($r=0.233$; $P=0.02$) and factsheets ($r=0.294$; $P=0.004$) than younger growers. In short, the Extension may be more likely to reach IPM and organic growers who have been growing for a longer time, growers who make more money from

blueberries, and growers who are older.

Table 12. Average rating of influential factors for each farm group, ordered highest to lowest according to pooled rankings of all growers together. ANOVA and Tukey analyses were conducted. Grower group means not followed by the same letter are significantly different.

Influences in Decision-Making *1: not influential at all; 3: neutral; 5: highly influential*			
Extension recommendations	CVT	**4.00b**	
1	IPM	**4.69a**	
	NS	**4.09ab**	Total Average:
	ORG	**4.42ab**	4.30
factsheets/bulletins	CVT	4.00	
2	IPM	4.60	
	NS	4.45	Total Average:
	ORG	4.00	4.26
Other farmers, family, or neighbors	CVT	3.83	
3	IPM	3.74	
	NS	3.67	Total Average:
	ORG	4.08	3.83
Extension workshops/meetings	CVT	**3.18b**	
3	IPM	**4.38a**	
	NS	**3.89ab**	Total Average:
	ORG	**3.82ab**	3.82
Ext. demonstration plots	CVT	**2.45b**	
4	IPM	**3.70a**	
	NS	**3.70ab**	Total Average:
	ORG	**2.91ab**	3.19
websites	CVT	2.67	
5	IPM	3.06	
	NS	2.60	Total Average:
	ORG	2.30	2.66
State or Federal Government	CVT	2.17	
6	IPM	2.93	
	NS	2.27	Total Average:
	ORG	2.08	2.36
media (newspaper, TV, movies)	CVT	2.25	
7	IPM	2.18	
	NS	2.80	Total Average:
	ORG	2.15	2.35
agricultural/pesticide companies	CVT	2.08	
8	IPM	2.42	
	NS	2.00	Total Average:
	ORG	1.58	2.02

Comparisons to Past Studies

Then versus Now

A study by Metzger and Ismail (1976) summarized management practices of wild blueberry growers in 1974, and table 13 compares the data from 1974 to the present study. They surveyed all growers on the University of Maine Cooperative Extension mailing list. Most growers in 1974 likewise used a two-year pruning cycle, letting half of their crop fruit while pruning the other half. The 1976 study made more differentiations between types of burning, including burning by hay, burning by hay *and* either gas or oil, as well as straw *and* gas or oil. It is therefore difficult to say for certain whether burning with oil and burning with straw have increased since 1974. What is marked in Table 14 as "other" actually includes burning with oil in conjunction with other materials. In fact, the use of oil could have *decreased* from 1974 to 2010 if one considers that oil was counted under various headings in the earlier study. It is also likely that oil use was at an especially low point in 1974, due to the 1973 oil embargo which increased oil prices

Table 13. Comparison of management practices in 1974 vs. 2010. "Other" includes burning with: hay, gas, straw-hay, straw-gas, straw-oil, etc.

Practice	% in 1974	% in 2010	Difference in %
mowing	78	87	+9
Burning: oil	29	44	+15
Burning: straw	8	33	+25
Burning: other	58	not reported	
fertilizer use	19	74	+55
insecticide use	73	60	+13
herbicide use	42	76	+34
use of bees	23	79	+56

worldwide (Roeder 2005). Burning with straw alone also seems to have increased since 1974 by 25%. This may seem surprising because of the amount of labor involved, especially when other options are now available, but straw is likewise combined with hay and gas under "other," and the percent increase is probably much smaller than 25%.

Mowing, fertilizer use, herbicide use and bee use have increased since 1974. The data from 2010 include those who are actively using any type of bee for pollination, including honeybees, bumble bees, and other species of bee. It is most likely that Metzger and Ismail were referring only to honeybee importation, since the idea of encouraging native bees was not introduced until later. Importation of honeybees has been steadily increasing since the 1960s (Drummond 2002), and studies have emerged since then that show positive relationships between fruit yield and honey bees (Arras et. al. 1996).

A 1995 study likewise found an increase in the use of fertilization, bees, and herbicides in blueberry production, and also an increase in management of soil pH (Strick and Yarborough 1995). In 1974, there were very few herbicides on the market. Indeed, the increase in blueberry yields per acre over the last thirty years has been atrributed to improved weed management, including greater use of herbicides (Yarborough 2004).

Another aspect to consider in this comparison is the inclusion of organic and no-spray growers: In 2010, the practices of twelve organic growers and ten no-spray growers were considered, while in 1973, these types of growers were probably not counted. Organic farming was practiced informally beginning in the 1960s, but organic labels and a more stringent bifurcation of management styles did not take hold until the 1990s with the Organic Foods Production Act (Anonymous 2005). Thus, organic blueberry growers contributed to the overall management practices measured in 2010, but probably not in

1974.

Interestingly, the number of growers harvesting under 20 acres and over 100 acres has increased since 1974 (Table 14), while the number with medium-sized farms has decreased. Metzger and Ismail also collected information about costs per acre of each practice in 1974. They found that both medium and small-sized operations spent more

Table 14. Percent acres harvested per grower in 1974 vs. 2010

	% in 1974	% in 2010	difference in %
under 20	52	58	+6
21-50	23	20	-3
51-100	17	10	-7
over 100	7	11	+4

per acre on herbicide applications than large-sized farms, while small and large-sized farms spent more per acre on burning than medium-sized farms. Medium-sized farms in 1974 were spending less per acre on burning but more on herbicides. The researchers did not find any associations between size of operation and fertilizing costs or pollination costs. The decrease in medium-sized farms and the increase in small and large-sized farms might be explained by increased profitability of organic produce. Marra et. al. (1995) supports this idea. They looked at profitability of three production styles of Maine wild blueberry growers, and found that organic production was actually more profitable than either IPM or conventional. The increased value of organic blueberries, coupled with lower input costs, high demand, and limited supply of organic blueberries, are essential to helping small farms survive (Marra et. al. 1995).

Other Methods of Categorization, and Farmer Priorities

The growers in this study were given four choices under which to categorize their

management styles: IPM, Conventional, Organic, and No-Spray, but other studies have suggested different ways of categorizing growers. Chouinard et. al. (2008) grouped growers according to their motivations: "profit maximizing" (those motivated by profit alone); "ego-utility," (those motivated by environmental effects but only if personally beneficial to them as well); "social stewardship," (those motivated by duties to family, society, and/or future generations). Another study split growers into: "Environmental Stewards," "Production Maximizers," and "Networking Entrepreneurs" according to what each grower prioritized. They, along with others, found that growers rarely fall discretely into one category and that the average farmer's motivations are heterogeneous (Chouinard et. al. 2008; Kaine et. al. 2008). These authors suggest that, "While scientists and policymakers might desire everyone to adopt a whole spectrum of practices, a more effective approach might be to work with growers to aggregate practices into groups that correspond with specific management goals" (Brodt et. al. 2004). This makes sense, except that growers may have trouble placing their priorities in a ranked order, as the blueberry growers of Maine did; many blueberry growers expressed frustration at being asked to do this, and some ranked more than one factor as number one in priority. In the analysis, priorities were shown to be weakly correlated with income (those with more income place more importance on maintaining the value of the land) and with years of experience (those with more years place more importance on continuing their family's legacy), but no other significant relationships were found in terms of grower priorities.

Priorities, like management styles, also shift and change according to various cultural and financial incentives. Padel (2001) examined multiple instances of organic farm conversion and found that, initially, the decision was based on the desire to maintain

the value of the land and the future of the farm. Religious reasons were also cited. More recently, however, decisions to convert seem to be based on financial incentives and on concern for the environment (Padel 2001; Burton et. al. 1999). Similar changes in motivation have been noted in IPM growers as well. Nation-wide, evidence suggests that IPM growers may have initially adopted IPM practices out of concern for profit, but their goals may be shifting to be "more in line with the public's desire to reduce risks associated with pesticide use" both to human health and to the environment (Fernandez-Cornejo et. al. 1999). Because the priorities of growers are so heterogeneous and linked to very few other factors, it makes sense to continue categorizing growers by management style instead of by personal priorities.

Beliefs about Pesticide Safety

There is evidence from the present study that IPM and conventional growers tend to believe scientists will always be able to obtain new pesticides, and that legal pesticides must be safe, while organic and no-spray growers agreed with these two statements significantly less. It is known that legal pesticides are not always safe--DDT was once legal, after all, as were many other pesticides that are now banned (Baker et. al. 2002). There are also many aspects about the effects of pesticides—especially long-term effects--that we do not yet know, as well as externalities, such as impacts on public health, soil degradation, and groundwater contamination (Jensen and Yarborough 2004; Pimentel et. al.1998). The level of safety of a pesticide also depends on how accurately the person applying it is following the label.

On the other hand, those who apply pesticides may also understand more about particular aspects of environmental toxicology. Whitford (1993) summarizes

interpretations of social scientists in regards to pesticide safety:

> *Social scientists indicate that positive and negative perceptions are formed easily based on one's own experiences. Farmers are inclined to form a positive attitude about pesticides because there're familiar with risk and because the benefits of preventing crop destruction from pests can be observed easily and immediately.*

Organic and no-spray growers may know less about pesticide environmental toxicology since they use them less (if at all) or they may purposely seek out information regarding the toxicity of pesticides. Their beliefs are also affected by personal experience. One organic grower had had her farm managed conventionally by a large company until she was accidentally sprayed directly with insecticide. She developed serious health issues soon afterwards, which she linked to the insecticide (anonymous grower, personal communication 2010). Whether or not the insecticide was a direct cause of the ensuing health problems, it is obvious why such an experience would cause one to have adverse beliefs toward the safety of pesticides. This farmer later converted her farm to organic. Similarly, a farmer who has seen drastic decreases in his returns because of failure to apply a pesticide may be wary of refraining from applying the pesticide the next year.

Other studies have also shown that those who use pesticides tend to have more confidence in their safety compared to those who do not use them (Nieuwenhuijsen et. al. 2005; Coppin et. al. 2002), and that women, younger adults, and more highly education people tend to trust pesticides less (Coppin et. al. 2002). One study specifically compared the beliefs of IPM versus conventional growers in beliefs about pesticide safety. The

researchers found that conventional growers tended-- more than the IPM growers-- to believe that farming activities do not have serious effects on the environment, and that pesticides do not have negative effects on nature (Papdaki-Klavdianou et.al. 2000).

While many pesticides are dangerous, it would be incorrect to assume that all are dangerous. Because each pesticide behaves differently in the environment, people who do not use them regularly may not understand the differences between different pesticides, and may therefore choose to be mistrustful of all pesticides as a rule of thumb (Govindsamy and Italia 1997). This is an example of Bounded Rationality, in which a person chooses a few salient factors on which to base their decisions. Many studies have been conducted on how people assess risk: People tend to have less trust in something when they feel they do not fully understand it, do not have control over the outcome, or when there is uncertainty involved (Blake 1995). In addition to developing stricter standards for measuring the practices of IPM growers, Extension might also consider educating the public about the specific functions and modes of breakdown of pesticides in the environment. This might be achieved through workshops that are specifically geared toward the public (instead of toward growers), or through public service announcements via the internet.

Demographic Comparisons

A 2006 survey of organic blueberry growers found that most organic growers farm part-time, earn additional income from other jobs, and tend to have smaller farms than conventional or IPM growers (Files et. al. 2008). The present study found similarities in regards to organic growers and farm size. It also found that all growers on average, no matter the management style, tend to earn income elsewhere, and that more

IPM and organic growers grow full-time than conventional or no-spray. World-wide, organic growers of various crops have been found to be younger in age, newer to farming, and more highly educated than conventional growers (Egri 1999; Padel 2001; Lockeretz 1997; Koesing et. al. 2008; Shennan et. al. 2000). However, some studies have found no differences between organic and conventional farmers in these demographics (Jamigaard 1991; Lockeretz and Wernick 1980). Like the latter studies, there was no correlation found between farm type and age or education among Maine wild blueberry growers, but, like the former studies, organic and no-spray growers were found to be newer to blueberry production than the other two grower groups. We did not ask growers for estimates of their income in dollars, we only asked for the proportion of their income that comes from blueberries.

Influences

This study found that IPM and organic growers attend University of Maine Cooperative Extension meetings more regularly than no-spray and conventional growers, and that both groups depend on blueberries for significantly more of their income than no-spray or conventional growers. Those for whom blueberry growing is a livelihood may put more effort into learning about research-based practices and may be more likely to incorporate suggestions from Extension. Similar results were reported in 2000 by researchers in Greece, who found that growers with more income tend to be more involved with extension (Papadaki-Klavdianou et. al. 2000).

Studies in other states and of other cropping systems have suggested that organic growers feel Extension has little to offer them, since many workshops are geared towards helping pesticide applicators become certified, and since the operators of smaller farms

hold other jobs and might therefore not be available during the times when Extension meetings are offered. These studies suggest that organic growers rely more on each other as sources for information, and on smaller, sustainable agriculture groups, rather than on Extension (Tavernier and Tolomeo 2004; Padel 2001; Egri 1999; Aguna 1995; Hanson et. al. 1995; MacRae et al. 1990). One of these studies reported that governmental Extension services spent little time promoting organic practices (Egri 1999). This was not found to be true for Maine wild blueberry growers, as evidenced by the percentage of growers who attend Extension meetings regularly (54%) and by the level of influence that Extension has in their decision-making (Table 13), as well as the positive ratings of Extension by growers of all farm types, including organic growers. This may be due to the special effort made by the faculty of the Maine Wild Blueberry Extension group to hold meetings in the evening or on weekends, while other extension services might only hold meetings during the day. Extension also offers one or more meetings per year specifically geared toward organic practices. Even though attendance is not required of organic growers, since most do not need to hold a pesticide applicators license, about half attend regularly. One would expect no-spray growers not to be as influenced by Extension, but they also attend the meetings regularly to some degree (30%) and are more influenced, on average, by Extension than they are by other factors.

The 2006 survey of organic wild blueberry growers in Maine showed that the preferred method of learning among organic growers varied from hands-on demonstrations, to University of Maine Cooperative Extension lectures and workshops, to trade journals, and the internet (Files et. al. 2008). In the 2010 study, I asked for information regarding factors of influence in decision-making and found that IPM

growers were significantly more influenced than other growers by factors relating to Extension, including factsheets, meetings, and demonstration plots, but that growers of all management styles rated Extension outreach as highly influential. "Other farmers, family, or neighbors" were also influential to all growers. This may be an example of Path Dependence: IPM growers are already required to attend Cooperative Extension meetings in order to maintain their pesticide license, and may therefore not feel a need to seek information from elsewhere.

Maine's Cooperative Extension offers several online services, such as forecasting, newsletters, updates and announcements about grower meetings, and information about new research and how to monitor fields effectively. The effects of mass media when it comes to farmer practices have been poorly studied, especially in cases where mass media is not readily available to community members (Ricker-Gilbert et. al. 2008). Maine wild blueberry growers may have limited access to the Internet and other media sources, as growers of all management styles rated Internet and media as barely influential at all.

Merging the Categories?

A section of the survey asked growers about IPM methods employed, and many similarities were found between IPM and conventional growers. There was no difference between the two in their employment of the following practices: leaving an unsprayed buffer around their fields ($P=0.79$), selecting pesticides that are friendlier to the environment ($P=0.69$), or using perimeter insecticide applications to manage pests ($P=0.08$). However, IPM growers are more likely than conventional to monitor their fields to determine if and when pesticides are needed ($P<0.001$), and they may be more

likely than conventional growers to take leaf tissue samples to determine if and when fertilizer is needed (P=0.058). Conventional and IPM growers both use pesticides, fertilizer, and import honeybees, and both prune by oil burning and by mowing. But there are some differences as well: Conventional growers harvest fewer acres than IPM, make less money from blueberries, and are less likely to attend Cooperative Extension meetings, which makes them less influenced by extension-related events, meetings, and demonstration plots than IPM growers. They also use fewer pesticides than IPM growers, on average, and tend to have lower toxicity ratings than these growers. For the purpose of the argument to follow, and because the two groups are very similar to each other in many regards, we will consider IPM and conventional as one group, called, "Pesticides Used."

No-Spray growers are very similar to organic, save for a few small differences. No-Spray growers use fertilizer while organic use sulfur; they make less of their income from blueberries than organic growers, are less likely to grow blueberries full-time, and they are less likely to attend Extension meetings regularly. But because of the similarities in their beliefs about pesticide safety and in their practices, we will consider organic and no-spray growers as one group when we discuss the Diffusion of Innovations Theory, and we will label this group, "Low-to-No Pesticides Used." We might also think in terms of "high intensity" management versus "low intensity" (Table 15):

Table 15. Merging the Categories

Pesticide used:		**Low-to-No pesticide used:**	
High intensity:	Low intensity:	High intensity:	Low intensity:
IPM	**Conventional**	**Organic**	**No-Spray**

When analyzed as just two groups, The "Pesticides Used" group can be characterized by their use of fertilizer, pesticides, and honeybees, by their higher toxicity rating than the "Low-to-No Pesticides Used" group, and by their confidence in the safety of pesticides. Their top priorities include: making a profit, maintaining land value, and providing healthy food for the public. "Low to No Pesticide" growers can be characterized by their minimal to non-use of pesticides, and by their use of fewer commercial bees. Their top priorities include: providing healthy food for the public, making a profit, and being a steward of the environment (Table 16).

Table 16. Percentage of growers placing factor among their top three priorities.

	land value	profit	healthy food	Maine culture	family legacy	out-doors	steward -ship	re-search	open land	Com-munity
Pesticides	77%	80%	61%	34%	59%	48%	41%	23%	45%	29%
Low-to-No Pesticides	54%	63%	71%	25%	29%	38%	58%	38%	42%	25%

Diffusion of Innovations Theory

Everett M. Rogers lays out the Diffusion of Innovations Theory in his 1971 book, Communication of Innovations, a Cross-Cultural Approach. In it, he describes patterns in groups of people who are most likely to adopt a new technology or innovation. He divides people into five groups: Innovators, Early Adopters, Early Majority Adopters, Late Majority Adopters, and Laggards. Those who come up with new ideas (Innovators) and those who are the first to adopt those new ideas (Early Adopters), the theory says, are more likely to be younger, more highly educated, and more in touch with outside sources of information than are laggards and late adopters. In blueberry growers, as discussed

earlier, I will use adoption of non-honeybee pollinators (such as bumble bees and other native bees) as the new technology to be adopted, since this practice was introduced relatively recently (see Tables 4 and 5).

Higher percentages of IPM and organic than conventional and no-spray are adopting new practices regarding native pollinators. When examined in this light, as well as in the light of the new, combined categories of "Pesticides Used" and "Low-to-No Pesticides Used," early adopters and laggards, or later adopters, begin to appear. IPM growers may be considered the early adopters of the "Pesticides" group, and conventional the later adopters, while organic growers are the early adopters of the "Low-to-No" group, and no-spray growers are the later adopters of that group. Indeed, the two early adopter groups have more contact with change agents (the Extension) than the later adopter groups. Roughly forty percent of each laggard group do not attend extension meetings because they are too far away, while over fifty percent of both early adopter groups attend extension meetings regularly (see Table 8).

Contrary to Rogers' theory, however, education and age seem to be unrelated to management style and unrelated to innovation adoption. The growers we have now termed early adopters are no younger and no more educated than the later adopters. None of the four management style groups is significantly younger than any other, even when only the two, over-arching groups were considered.

Rogers also describes differences in how information is acquired. Knowledge about a new technology, he says, is often acquired through mass media avenues, whereas attitudes towards the new technology are often formed via personal information sources. Mass media, however, including newspapers, television, movies, and websites, were not

believed by the Maine blueberry growers to be influential to them in their decision-making. This may mean that both knowledge about and attitudes towards new technology come from the same sources. Growers who attend the cooperative extension meetings and demonstrations may be obtaining knowledge about new practices while at the same time being influenced in their attitude towards those new practices. In short, this data supports parts of Rogers' theory, but refutes other parts, and it might be more effective to consider the blueberry growers of Maine as acting within two different communities which sometimes overlap: "Pesticides Used" and "Low-to-No Pesticides Used."

Fulfilling the Goals of IPM

Integrated Pest Management (IPM) may be defined differently depending on whom you ask (Blake et. al. 2006; Epstein and Bassein 2003; Shennan et. al. 2000). The Northeastern IPM Center defines IPM as, "A science-based approach to managing pests in ways that generate economic, environmental, and human health benefits." The USDA (Anon. 2004) lays out the following "roadmap" of goals for IPM:

> *The fundamental principles expressed in the National IPM Roadmap are: 1) to improve the economic benefits related to the adoption of IPM practices, 2) to reduce potential human health risks from pests and the use of pest management practices, and 3) to reduce unreasonable adverse environmental effects from pests and the use of pest management practices. The National IPM Roadmap guides all IPM programs administered by the Federal Government.*

Considering that one of the major, national goals of IPM has been to address environmental concerns and reduce pesticide use (Fernandez-Cornejo and Jans 1999), one must ask whether IPM is fulfilling those goals, and whether it is really all that

different from conventional. A few explanations for the findings in the present study are discussed in this section.

In addition to considering the problems associated with the toxicity ratings, as discussed earlier, it is possible that IPM growers required more pesticide input during 2010 because of increased pest pressure for that year. The IPM method involves monitoring for pests and applying when and where necessary, but there may be some years when growers discover they need *more* pesticide than they would otherwise have used.

Epstein and Bassein (2003) point out that pesticide use overall among California IPM growers actually increased 4% between the years 1993 and 2000, but a study put out by the US Government Accounting Office showed that use of the "riskiest" pesticides (as defined by the EPA) has declined by 14% (Anon. 2001). In other words, more pesticides than before may now be in use, but individually they are less toxic.

Another aspect to note is that conventional blueberry growers may not be equivalent to conventional growers in other cropping systems. Typically, the term "conventional" is applied to large, industrial farms that are highly mechanized (Comer et. al 1999). Conventional blueberry growers, however, might be more aptly termed, "Traditional." It is evident from the current data that this category includes growers who have been growing blueberries on their land for generations. They are also more concerned with continuing their family's legacy and less concerned with profit, on average, than the other three groups. In some ways, these "Traditional" growers might be thought of as the "Maine Yankees" of blueberry growing: they follow their own path, earn income from various sources, and continue growing where the last generation left

off. When taken in this context, it makes sense that IPM growers would manage their fields more intensively, and have higher toxicity ratings on average than conventional or "traditional."

A Shift in the Naming Convention?

It is also possible that a shift in the naming convention has occurred, as many growers may realize the negative connotations associated with the term, "conventional." Growers of various crops in California were asked over the phone to name their degree of IPM adoption. Their actual practices were then compared to their beliefs of their own level of adoption. Fifty-two percent of the growers said they used more than a minimum level of IPM, but only 29% could be classified as actually using IPM more than minimally (Shennan et. al. 2000). Another study, conducted in 2000, showed no significant differences between IPM and conventional tomato growers in cultivation practices (Papadaki-Klavdianou et. al. 2000). However, these studies compared IPM growers to "industrialized conventional" growers, and conventional blueberry growers may be more aptly thought of as "traditional" growers.

My study found that growers who call themselves IPM versus those who call themselves conventional are very similar in the practices they employ, but that IPM growers monitor for insects and take leaf tissue samples significantly more than conventional. This may be the main characteristic that IPM blueberry growers use to define their growing style. It may also be that IPM practices that were once "cutting edge" are now becoming more "main stream" and conventional growers are adopting them as well, even if those growers do not call themselves IPM.

Some have criticized studies of IPM adoption, saying that insect monitoring is the only way its success has been measured, even though many other practices are involved (Zalucki et. al. 2009). Others point out that there are no practices that officially disqualify growers from calling themselves IPM (Epstein and Bassein 2003). Extension educators may define certain practices, such as calendar year spraying, as disqualifying a grower from IPM status, but some growers may have different ideas regarding the practices associated (or not associated) with IPM. Because the distinction between IPM and Conventional is not clear in some regards, and also because the practices involved in IPM are so varied, it might be worth looking into an IPM certification program for the state of Maine.

IPM Certification Programs

In the mid-nineties, the University of Massachusetts piloted a program for IPM certification (Hollingsworth 1994), and Cornell University in New York researched an IPM labeling program. Growers in these programs are permitted to label their food as IPM only if they earn enough points (assigned to each IPM practice) to prove they practice IPM (Anderson et. al. 1996). This point and label system has given IPM growers in these states further incentive to reduce their use of pesticides and diversify their methods. Produce labeled as IPM under an official certification process has also been shown to have lower levels of pesticide residues than produce that was not certified (although IPM produce had more residues than organic) (Baker et. al. 2002). Studies have been conducted to determine whether consumers would buy products labeled as IPM-certified and the results have been encouraging. While few of those surveyed knew

what IPM meant at the start of the survey, most (over 70% in each study) said they would prefer to buy IPM-certified produce once they understood what it meant (Anderson et. al. 1996; Govindasamy et. al. 1998). Perhaps if a certification and labeling system were implemented in Maine for wild blueberries, both growers and consumers would better understand the practices associated with IPM.

However, the decision to standardize the practice of IPM is tricky. Being officially certified may not necessarily indicate anything about the practices and beliefs of the grower, as can be seen in the present blueberry study with the lack of major differences in those regards between organic and no-spray growers. Many studies have documented the frustration expressed by organic and would-be organic growers at the certification process. Some organic growers feel that the process lowers the standards of this type of farming, and some feel it is too stringent so as to encourage larger, more industrial farms to obtain the certification, while discouraging small farms (Guthman 1998; Vos 2000; Nelson 2007; and Pers. Comm from various growers). Some of the no-spray growers in the present study might be growers who are organic in most regards but who do not wish to go to the trouble or cost of becoming certified, or who use a small amount of herbicide, which disqualifies them from organic status. Despite the issues that could be associated with standardization, it would be worth looking into the feasibility of an IPM certification program for the state of Maine. Such a program could give farmers incentive to use less pesticide, as well as create more awareness about IPM among the public.

CONCLUSION

Wild blueberry growers in Maine were asked to place themselves into one of four categories provided: Conventional, IPM, Organic, and No-Spray, and those categories were then analyzed for correlations to practices, beliefs about pesticide safety, priorities, and influences. The practices of IPM growers were found to be more similar to what was expected for conventional growers in terms of toxicity ratings and beliefs about pesticide safety. Two major differences in practices include higher levels of monitoring for insects on the part of IPM growers, and taking leaf tissue samples. Conventional blueberry growers might more aptly be termed, "Traditional growers," since they are more concerned with maintaining their family's legacy than with profit, and since their management practices are less intensive than IPM.

No-Spray growers were found to be very similar to organic, save for use of fertilizer by the former and use of sulfur by the latter. IPM and organic growers depend more on blueberries for their income than the other two groups, and top priorities for all growers include making a profit. It might be useful to think of blueberry growers as two separate communities in which there is some overlap: "Pesticides Used" and "Low-to-No Pesticides Used." Within these two communities, IPM growers might be considered the "Early Adopters" and conventional the "Laggards," while the same can be considered of organic and no-spray growers, respectively.

Policymakers might consider an IPM certification program for the state of Maine to help further decrease pesticide use, and to increase public awareness of this management style.

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APPENDIX: 2010 Survey for Blueberry Growers

This survey is being conducted by University of Maine graduate student, Anya Rose, as part of the Cooperative Extension program for blueberry growers. Your participation is completely voluntary. You do not have to answer any question you do not want to. Your responses will remain anonymous and confidential. There are six parts to the survey, and it should take about 20 minutes to complete. Please use the enclosed, stamped envelope to return your survey by May 31st. If you have any questions, Anya can be reached at: (215) 514-3745. Feel free to use the white space to expand on any answers.

I. Scientist-Grower Relationships.

We would like to know of your personal experiences, interactions with, and beliefs about scientists and Cooperative Extension researchers.

1. Please tell us your level of agreement with each of the following statements about blueberry researchers and Cooperative Extension faculty:
(please read carefully!)

1: strongly disagree **2: slightly disagree** **3: neutral** **4: slightly agree** **5: strongly agree**	**1**	**2**	**3**	**4**	**5**
a. The Cooperative Extension provides a lot of useful information about the environment.					
b. The Cooperative Extension does not understand the needs of growers.					
c. Scientists will be able to research new pesticides when insects become resistant to the current ones.					
d. I have employed practices suggested by the Cooperative Extension.					
e. I have not been satisfied with the practices I employed that were suggested by the Cooperative Extension.					
f. The Cooperative Extension is not receptive to grower suggestions, and to grower-developed innovations.					
g. Legal pesticides must be safe, since they were approved by the pesticide board.					
h. I trust the Cooperative Extension to provide accurate information.					
i. The Cooperative Extension is not helpful in developing useful policies for blueberry growers.					
j. The Cooperative Extension has proposed methods which would reduce my costs or increase my returns.					
k. The Cooperative Extension/University researchers communicate on a level which I cannot understand.					
l. I have had positive interactions with University researchers or educators from the Cooperative Extension.					

Anything else you'd like to add:

II. Factors of Personal Importance

We would like to know about your reasons for being a blueberry grower. Why do you do it? What is most important to you? What is least important? Please use the ranking system below.

2. How important are the following to you? (*please rank from 1-10 and use each number only once.)*

1: this is the most important to me 2: second-most important to me 3: third-most important to me, etc. 10: this is the least important to me	Use each number only once	**Rank number (1-10)**
a. maintaining the value of my land		
b. making a profit (more than enough to break even)		
c. providing healthy food for the public		
d. being a part of Maine's blueberry culture		
e. continuing my family's legacy		
f. spending time outdoors		
g. being a steward of the environment		
h. helping to further scientific research		
i. keeping land open and undeveloped		
j. maintaining positive relations with the community		

k. Please write in anything else that is particularly important to you:

(go to next page)

III. Personal Background and Growing History

3. What is your gender?
Male ☐ Female ☐

4. Are you a resident of Maine?
full time ☐ part time ☐ not a resident ☐
a. If a resident , what county? _____
b. If not, what state? _____

5. How many months of the year do you spend in Maine?
_____ months

6. What is your age? _____

7. Do you grow blueberries as a full-time occupation?
Yes ☐ No ☐

8. What percentage of your income comes from the sale of blueberries?
_____**%**

9. Do you have someone else (a partner) who works with you on the farm?
Yes ☐ No ☐

If **Yes**, is that person a:
a. ☐ Spouse
c. ☐ Business partner
d. ☐ Relative
e. ☐ Other: _____

10. Is your blueberry farm organized as a:
a. ☐ Sole ownership
b. ☐ Partnership
c. ☐ Corporation

11. Do you own the land on which you harvest blueberries?
Yes ☐ No ☐

If **Yes**, (*please select all that apply)*:
a. ☐ I manage the land myself
b. ☐ I hire a manager
c. ☐ I harvest the land myself
d. ☐ I hire someone else to harvest from the land.

If **No**, (*please select all that apply)*:
e. ☐ I harvest from the land
f. ☐ I am the manager

12. How many miles away from your field(s) is the nearest occupied dwelling?

_____ miles

13. In the past year, have you been paid for work off the farm?

Yes ☐ No ☐

14. How many acres of blueberries do you harvest in a given year?

a. ☐ under 5 acres
b. ☐ 6 - 20 acres
c. ☐ 21 – 50 acre
d. ☐ 51 – 100 acres
e. ☐ 101 – 200 acres
f. ☐ 201 – 500 acres
g. ☐ 500 -1000 acres
h. ☐ over 1000 acres

15. What is the highest level of education that you have obtained? ***(choose one)***

a. ☐ Completed K thru 8th grade
b. ☐ Graduated high school
c. ☐ Attended college
d. ☐ Completed Bachelor's degree
e. ☐ Some graduate school
f. ☐ Graduate degree

16. What is the highest level of education your growing partner has obtained?

a. ☐ Completed K thru 8th grade
b. ☐ Graduated high school
c. ☐ Attended college
d. ☐ Completed Bachelor's degree
e. ☐ Some graduate school
f. ☐ Graduate degree
g. ☐ Not sure
h. ☐ I don't have a partner

17. For how many years have you been growing blueberries (*choose one)?*

a. ☐ Under 5 years
b. ☐ 5 – 10 years
c. ☐ 11 – 20 years
d. ☐ 21 – 40 years
e. ☐ over 40 years

18. How long has blueberry growing been a part of your family's income?
(please select all that apply)

a. ☐ I am a first-generation grower; my parents did not grow blueberries.
b. ☐ My parents were growers.
c. ☐ My grandparents were growers.
d. ☐ My great-grandparents were growers.

IV. Production and Management

We would like to learn more about how you manage your fields.

19. Do you prune your fields?

Yes ☐ No ☐

If **Yes**, do you:

a. ☐ Burn with straw
b. ☐ Burn with oil
c. ☐ Mow

If **Yes**, how often do you prune? (choose one)

d. ☐ Every other year
e. ☐ Every 3 years
f. ☐ More than every 4 years

If **No**, why don't you prune?

20. Fertility Maintenance: Do you fertilize?

Yes ☐ No ☐ sometimes ☐

If **Yes**,

a. Do you fertilize organically? Yes ☐ No ☐
b. Do you take leaf samples to determine when to add fertilizer?
Yes ☐ No ☐
c. What do you use for fertilizer and how often? (example: every prune year)

21. Weed Control: Do you cut weeds?

Yes ☐ No ☐

If **Yes**:

a. Do you use any herbicides?
Yes ☐ No ☐

b. How often do you apply (example: every prune year):

c. If Yes, what is/are the name(s) of the product(s)?

22. pH Control: Have you used sulfur to adjust the pH of your fields?

Yes ☐ No ☐

If Yes, how many times?

a. ☐ Once
b. ☐ More than once
c. ☐ More than twice

23. Pollination: Do you rent or buy bees to pollinate your blueberries?

Yes ☐ No ☐

If **No**, why Not? *(please write-in)*

If **Yes**, what kind? *(select all that apply)*

a. ☐ Honeybees
b. ☐ Bumblebees

If **Yes**:

c. How many hives/quads do you use per acre? _____
d. Do you own your own honeybee hives? Yes ☐ No ☐
e. Would you like to learn how to raise your own bees? Yes ☐ No ☐

24. Do you attempt to increase native bee populations?

Yes ☐ No ☐

If **Yes**, how? *(select all that apply)*

a. ☐ Hanging nesting blocks for native bees
b. ☐ Leaving dead trees to provide bee habitat
c. ☐ Using less harmful pesticides
d. ☐ Using no pesticides at all
e. ☐ Allowing other types of flowers to bloom in or around my fields.
f. ☐ Other:

25. Insect/Disease Control: In the past five years, have you used any insecticides or fungicides to control insect pests or diseases?

Yes ☐ No ☐

If Yes, please list each pest or disease, the associated control, and how often you apply it:

Pest/Disease	**Control:**	**# times applied per year:**
a.		
b.		
c.		
d.		
e.		

26. Do you think that insect predators such as ants or spiders help control insect pests? Yes ☐ No ☐

27. Should more research be conducted on insect predators?
Yes ☐ No ☐

28. Do you have a pesticide license?
Yes ☐ No ☐

If **Yes**, for how long have you had this license? (choose one)

a. ☐ 2 years or less.
b. ☐ 3-10 years.
c. ☐ More than 10 years.

If **No**, why not?

d. ☐ I have someone else spray.
e. ☐ I spray less toxic pesticides.
f. ☐ I do not spray any pesticides.
g. ☐ Other: _____
h. Are you planning to obtain this license soon? Yes ☐ No ☐

29. How would you describe your pesticide management style overall?
(choose a, b, c, or d)

a. ☐ Certified Organic *(choose A, B, or C)*
   A. ☐ No pesticides or herbicides at all are sprayed on my land.
   B. ☐ Only certified organic herb/pesticides are sprayed on my land.
   C. ☐ Other: _____

b. ☐ No Spray *(choose A, B, or C)*
   A. ☐ I am not organic certified, but I do not spray.
   B. ☐ I am not organic certified, but I only spray organic herbicides or pesticides.
   C. ☐ Other: _____

c. ☐ IPM (Integrated Pest Management)/Best Management *(choose A or B)*
   A. ☐ I monitor my fields to determine where pesticides and herbicides are needed and I only spray in the necessary places.
   B. ☐ Other: _____

d. ☐ Conventional / Traditional (*choose all that apply*):
   A. ☐ I spray according to the calendar year
   B. ☐ I spray according to when pesticide applicators are available
   C. ☐ I spray but try to use less than what the directions say
   D. ☐ I spray a little extra than what the label says, "just in case."
   E. ☐ Other: _____

30. Do you attend Cooperative Extension meetings regularly?

Yes ☐ No ☐

If Yes, what is your primary purpose in attending? *(check all that apply)*

a. ☐ To attain credits towards my pesticide applicator's license.
b. ☐ Out of curiosity, and to learn new things
c. ☐ To convene with other growers.
d. ☐ Other: _____

If not, why not? *(check all that apply)*

e. ☐ I live too far away from where they are held
f. ☐ I do not find them useful
g. ☐ I never know when they will be.
h. ☐ Other: _____

V. Changes

We would like to get a sense for how the blueberry industry is changing. The following questions are about changes in your growing practices.
Please make sure to address your reasons for answering yes or no.

31. Do you use bumblebees for pollination?

Yes ☐ No ☐

If **Yes**:

a. ☐ I recently started doing this, within the past 2 years
b. ☐ I have been doing this for over 2 years.

If **Yes**, please describe why and note any benefits you've experienced:

If **No**:

c. ☐ I do not intend to try this.
d. ☐ I intend to try it within the next 2 years.
e. ☐ I have tried this, but have been unsatisfied with the results.

If **No**, why not? *(select all that apply)*

f. ☐ Too costly.
g. ☐ I do not believe they are any more effective than honeybees.
h. ☐ I believe it would be too labor intensive.
i. ☐ I don't know enough about it.
j. ☐ Other: _____

32. Do you leave an unsprayed vegetative buffer around your fields?

Yes ☐ No ☐

If **Yes**:

a. ☐ I recently started doing this, within the past 2 years
b. ☐ I have been doing this for over 2 years.

If **Yes**, please describe why, and note any benefits you've experienced:

If **No**:

c. ☐ I do not intend to try this.
d. ☐ I intend to try it within the next 2 years.
e. ☐ I have tried this, but have been unsatisfied with the results.

If **No**, why not? *(select all that apply)*

f. ☐ Too costly.
g. ☐ I do not believe it does anything to help.
h. ☐ It would be too labor intensive.
i. ☐ I don't know enough about it.
j. ☐ Other: _____

33. Do you take plant leaf samples to determine exactly where fertilizer is needed?

Yes ☐ No ☐

If **Yes**:

a. ☐ I recently started doing this, within the past 2 years
b. ☐ I have been doing this for over 2 years.

If **Yes**, please describe why, and note any benefits you've experienced:

If **No**:

c. ☐ I do not intend to try this.
d. ☐ I intend to try it within the next 2 years.
e. ☐ I have tried this, but have been unsatisfied with the results

If **No**, why not? *(select all that apply)*

f. ☐ Too costly.
g. ☐ It's easier to fertilize everywhere.
h. ☐ I do not believe it's effective.
i. ☐ I believe it would be too labor intensive.
j. ☐ I don't know enough about it.
k. ☐ Other: _____

34. Do you monitor fields to determine exactly if and when pesticides/herbicides are needed (*refers to both organic and non-organic*)?

Yes ☐ No ☐

If **Yes**:

a. ☐ I recently started doing this, within the past 2 years
b. ☐ I have been doing this for over 2 years.

If **Yes**, please describe why, and note any benefits you've experienced:

If **No**:

c. ☐ I do not intend to try this.
d. ☐ I intend to try it within the next 2 years.
e. ☐ I have tried this, but have been unsatisfied with the results

If **No**, why not? *(select all that apply)*

f. ☐ Too costly.
g. ☐ I do not believe it's effective.
h. ☐ It's easier to spray the whole field all at once.
i. ☐ I believe it would be too labor intensive.
j. ☐ I don't know enough about it.
k. ☐ Other: _____

35. Do you purposely select pesticides that have lower environmental impact or reduced risk (refers to both organic and non-organic pesticides)?

Yes ☐ No ☐

If **Yes**:

a. ☐ I recently started doing this, within the past 2 years
b. ☐ I have been doing this for over 2 years.

If **Yes**, please describe why, and note any benefits you've experienced:

If **No**:

c. ☐ I do not intend to try this.
d. ☐ I intend to try it within the next 2 years.
e. ☐ I have tried this, but have been unsatisfied with the results.

If **No**, why not? *(select all that apply)*

f. ☐ Too costly.
g. ☐ I do not believe it does anything to help the environment.
h. ☐ Having a lower impact on the environment is not one of my priorities.
i. ☐ I believe it would be too labor intensive.
j. ☐ I don't know enough about it.
k. ☐ Other: _____

36. Do you note nearby water sources and wind direction before spraying, and/or do you refrain from spraying during certain weather conditions (refers to both organic and non-organic pesticides)?

Yes ☐ No ☐

If **Yes**, why? *(select all that apply)*

a. ☐ It's the law and I have to.
b. ☐ I want to have less of an impact on the environment.
c. ☐ I am concerned about the water table.
d. ☐ I don't want my neighbors to complain.
e. ☐ Other:

If **No**, why not? *(select all that apply)*

f. ☐ I do not see how it helps.
g. ☐ Too costly.
h. ☐ Takes too much time.
i. ☐ I don't believe pesticides are that toxic.
j. ☐ I don't know enough about it.
k. ☐ Other: _____

37. Do you use perimeter insecticide applications to manage pests?

Yes ☐ No ☐

If Yes, why? (*select all that apply)*

a. ☐ It saves money.
b. ☐ It works as well as treating the whole field.
c. ☐ It saves time.
d. ☐ It lessens the impact on bees.
e. ☐ Other: _____

If No, why not? *(select all that apply)*

f. ☐ I don't trust it, too risky.
g. ☐ It doesn't work.
h. ☐ I depend on helicopters or other applicators that don't want to do it.
i. ☐ It's too much of a hassle.
j. ☐ Other: _____

(turn to next page)

VI. Influences and Communication

For this study, communication is considered effective or influential if a grower implements a new practice because of new information given. Communication is considered not influential if very few growers actually implement the new practice.

38. What sources have been influential to you in your adoption of new farming practices?

1: not influential at all 2:slightly not influential 3: neutral 4: slightly influential 5: highly influential	**1**	**2**	**3**	**4**	**5**
a. Leads from other farmers, family, or neighbors					
b. Recommendations from University Extension or researchers					
c. Pressure or encouragement from the State or Federal government					
d. Financial incentives from agricultural or pesticide companies					
e. Newspaper articles, TV, or movies (online or otherwise)					
F .Blueberry grower websites please specify website(s) most used:					
g. Extension demonstration plots					
h. Extension workshops and meetings:					
i. Educational pamphlets/factsheets/bulletins					

j. When you need information on a particular topic, how do you find it? (*Please explain)*

39. Anything else you'd like to add:

Your participation in this survey is greatly appreciated. Thank you!

BIOGRAPHY OF THE AUTHOR

Anya Rose grew up in the city of Philadelphia, PA and attended a "magnet" high school that specialized in math and science. She completed her Bachelor of Arts at Bard College in NY, where she designed a multidisciplinary major of, "Children's Educational Media."

She spent two summers during college working in outdoor education on Nantucket, and later taught nature appreciation, team building, and science classes for Nature's Classroom in Massachusetts. From 2005-2007, she taught wilderness survival skills for homeschoolers at White Pine Programs in southern Maine. She subsequently lived in Costa Rica for four months at a sustainable living center, where she taught music and English at the local elementary school, and hand-pollinated vanilla vines. She then worked in the Historic Landscapes department of the Strawbery Banke Museum in Portsmouth, New Hampshire.

During her time at the University of Maine, Anya assisted Dr. Daniel Bell in his research on blueberry pollination and genetics. She currently works for Public Relations at the University, creating short films about scientists and their work. She hopes to expand in the field of science and film. Anya is a candidate for the Master of Science degree in Ecology and Environmental Science from The University of Maine in December, 2010.